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January 1996

US Army Corps of Engineers
Waterways Experiment Station

Wave Information Studies of US Coastlines

Wave Information Study Annual Summary Report, Atlantic 1994

by Barbara A. Tracy, Alan Cialone

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Prepared for Headquarters, U.S. Army Corps of Engineers

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of US Coastlines

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U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Final report

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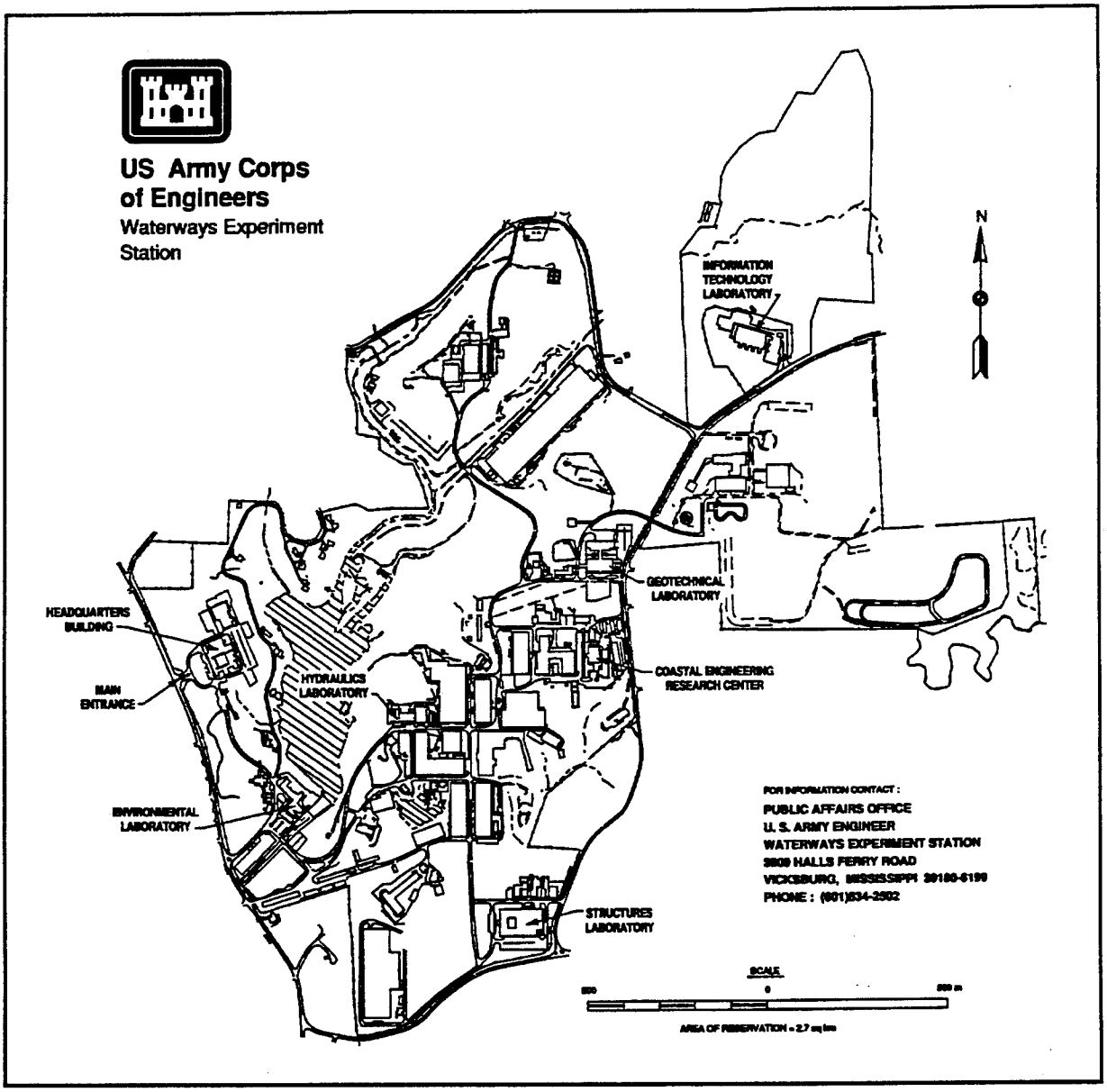

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Preface

In late 1976 a study to produce a wave climate for U.S. coastal waters was initiated at the U.S. Army Engineer Waterways Experiment Station (WES). The Wave Information Studies (WIS) was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE) as part of the Coastal Field Data Collection Program, which is managed by the WES Coastal Engineering Research Center (CERC). Messrs. John H. Lockhart, Jr., Charles B. Chesnutt, and Barry W. Holliday, HQUSACE, are Technical Monitors for the Coastal Field Data Collection Program; Ms. Carolyn M. Holmes is Program Manager, and Dr. Jon M. Hubertz, CERC, is WIS Project Manager.

This report, the 34th in a series, is a description of the Atlantic nowcast procedure and the 1994 Atlantic wave climatology. Wind products for the 1994 hindcast were obtained from the University Center for Atmospheric Research (UCAR) which archives the National Meteorological Center data. The authors appreciate the assistance of Ms. Ilana Stern, UCAR, in data transfer. Ms. Barbara Tracy, CERC, served as principal investigator for the Atlantic nowcast. Mr. Alan Cialone, CERC, produced data analysis and comparison results. Dr. Hubertz provided technical assistance.

The study was conducted under the direct supervision of Dr. Martin C. Miller, Chief, Coastal Oceanography Branch, CERC, and Mr. H. Lee Butler, Chief, Research Division, CERC; and under the general supervision of Dr. James R. Houston and Mr. Charles Calhoun, Jr., Director and Assistant Director, CERC, respectively.

At the time of publication of this report, Dr. Robert W. Whalin was Director of WES. COL Bruce K. Howard, EN, was Commander.

1 Introduction

Objective

The Wave Information Studies (WIS) project has provided wave information for nearshore U.S. Atlantic coast locations for 1956-1975, documented in WIS Report 30 (Hubertz et al. 1993), and for 1976-1993, documented in WIS Report 33 (Brooks and Brandon 1995). This information has provided coastal engineers in the U.S. Army Corps of Engineers and the private sector with an authoritative, long-term database with which to evaluate coastal processes and design appropriate management strategies for the coastline. A "nowcast" procedure was established to meet the need to update the wave database with recent information. The nowcast procedure uses wind information from the National Meteorological Center (NMC) to produce a monthly wave hindcast. This monthly hindcast can be completed approximately 6 weeks following the month on which it is based. Wave buoy data, measured at selected sites, are usually available about 2 months after the measurement period and are used to verify the numerical hindcast. When a hindcast has been completed and verified with measured data, the nowcast wave information is transferred to the Coastal Engineering Data Retrieval System (CEDRS) database (McAneny 1995). This report describes the nowcasting procedure for the Atlantic and provides a description and analysis of the wave climatology for 1994.

Approach

The NMC Global Winds were used to produce the wind fields for the wave hindcasts. The winds consist of u,v wind speed components every 6 hr at 10 m elevation on a global grid with a spacing of 0.9375 deg latitude and longitude. The September 1989 issue of *Weather and Forecasting* is devoted to papers on the NMC modeling system. An overview of the system is provided by Bonner (1989). Recent changes to the NMC global system are documented in Kanamitsu et al. (1991). This product replaces the Fleet Numerical Oceanography Center wind product (2.5-deg spacing) that was used for the 1976-1993 hindcast (Brooks and Brandon 1995).

The NMC global u,v wind components were transformed to the level 1 and level 2 Atlantic grid intersections. These grids (shown in Figures 1 and 2) are the same as the grids that were used to hindcast the 1976-1993 wave data. The level 1 wind fields (1-deg spacing) and the level 2 wind fields (0.25-deg spacing) were each interpolated separately from the global wind field. The few missing 6-hr wind fields were interpolated from the available 6-hr information on either side of the missing hour.

The latest version of the WIS wave hindcast model, WISWAVE 2.1, described in WIS Report 27 (Hubertz 1992), was used to produce the 1994 Atlantic wave hindcast. This is the same version of the model that produced the wave hindcast described in WIS 33 (Brooks and Brandon 1995). Data were saved at the same output locations as the previous Atlantic hindcasts. See Figure 3 for the location of the WIS output stations. These 1994 data are available from the CEDRS database. McAneny (1995) gives a description of the CEDRS data. Wave parameters including significant wave height, peak wave period, mean wave period, peak mean wave direction, wind speed, and wind direction are available at 3-hr intervals for the entire year for the stations in Figure 3. The 1994 nowcast is a continuation of the updated Atlantic hindcast (1976-1993), and Brooks and Brandon (1995) describe the output data in more detail.

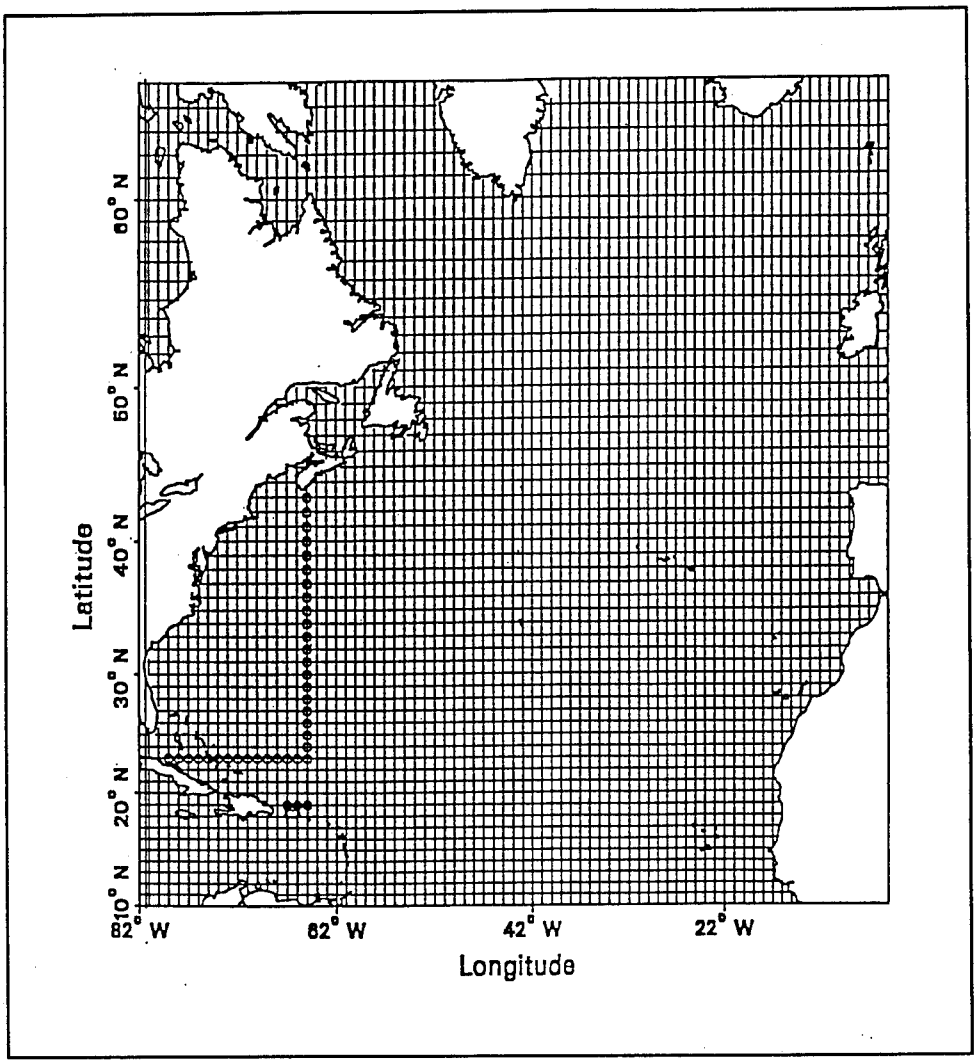


Figure 1. Level 1 Atlantic grid extended from latitude 10°N to 65°N (56 rows) and from longitude 82°W to 5°W (78 columns)

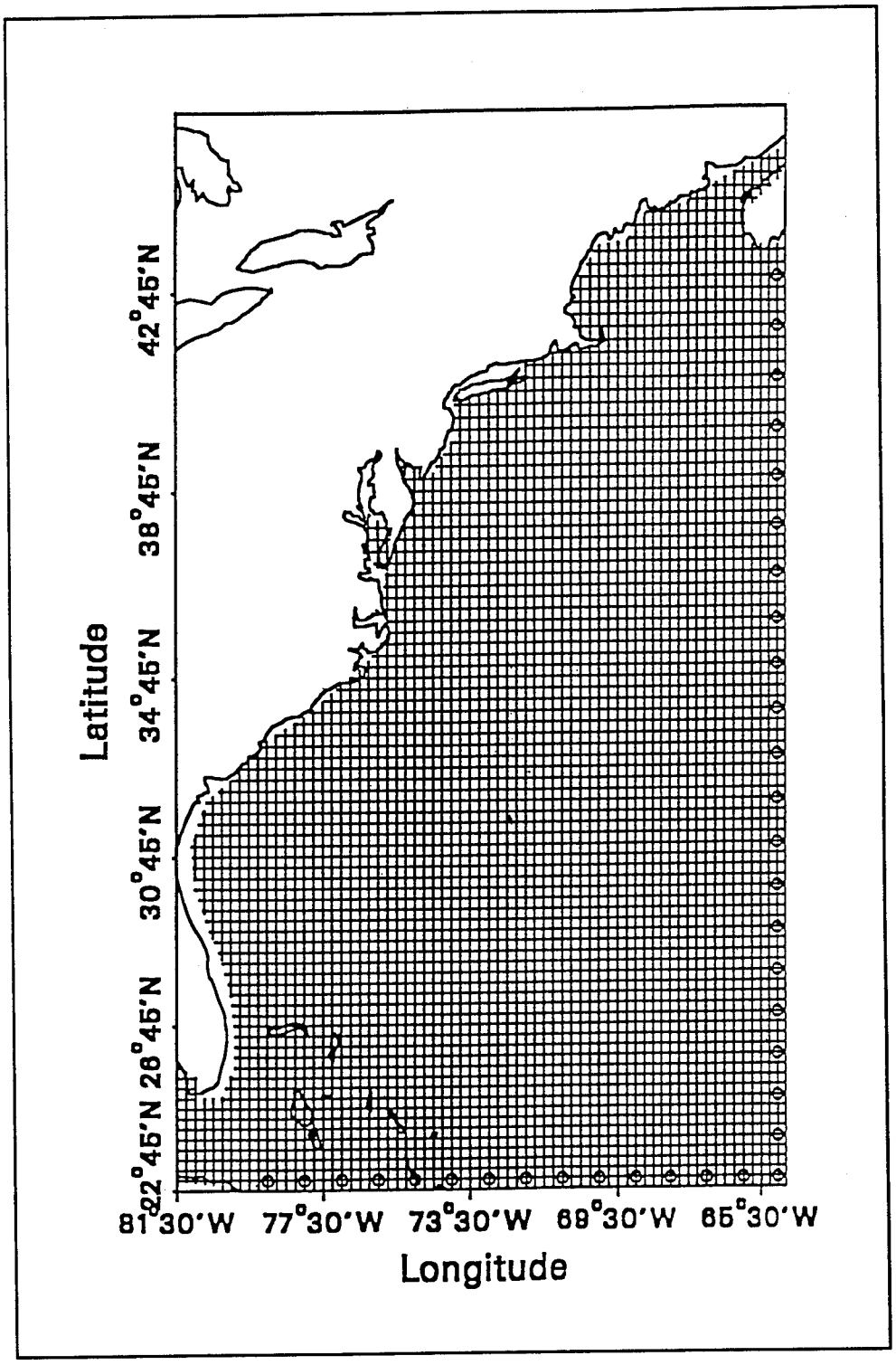


Figure 2. Level 2 Atlantic grid extended from latitude 22.75°N to 45.25°N (91 rows) and from longitude 81.5°W to 64.75°W (68 columns)

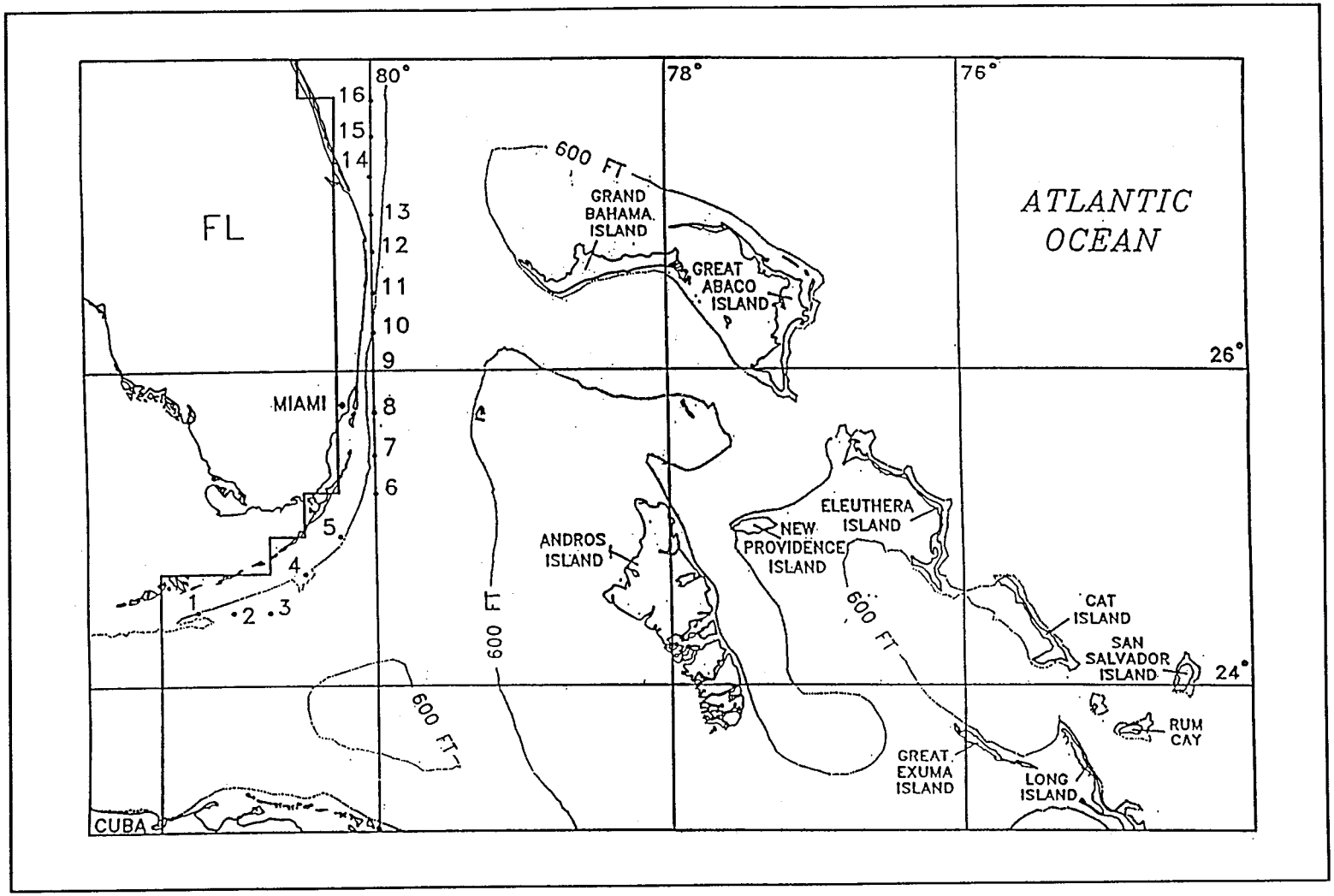


Figure 3. Location of WIS stations (solid dots), National Oceanic and Atmospheric Administration (NOAA) buoys (circled dots), land/water boundary (solid thin line, actual; solid wide line, model), and continental shelf boundary (dotted line) (Sheet 1 of 4)

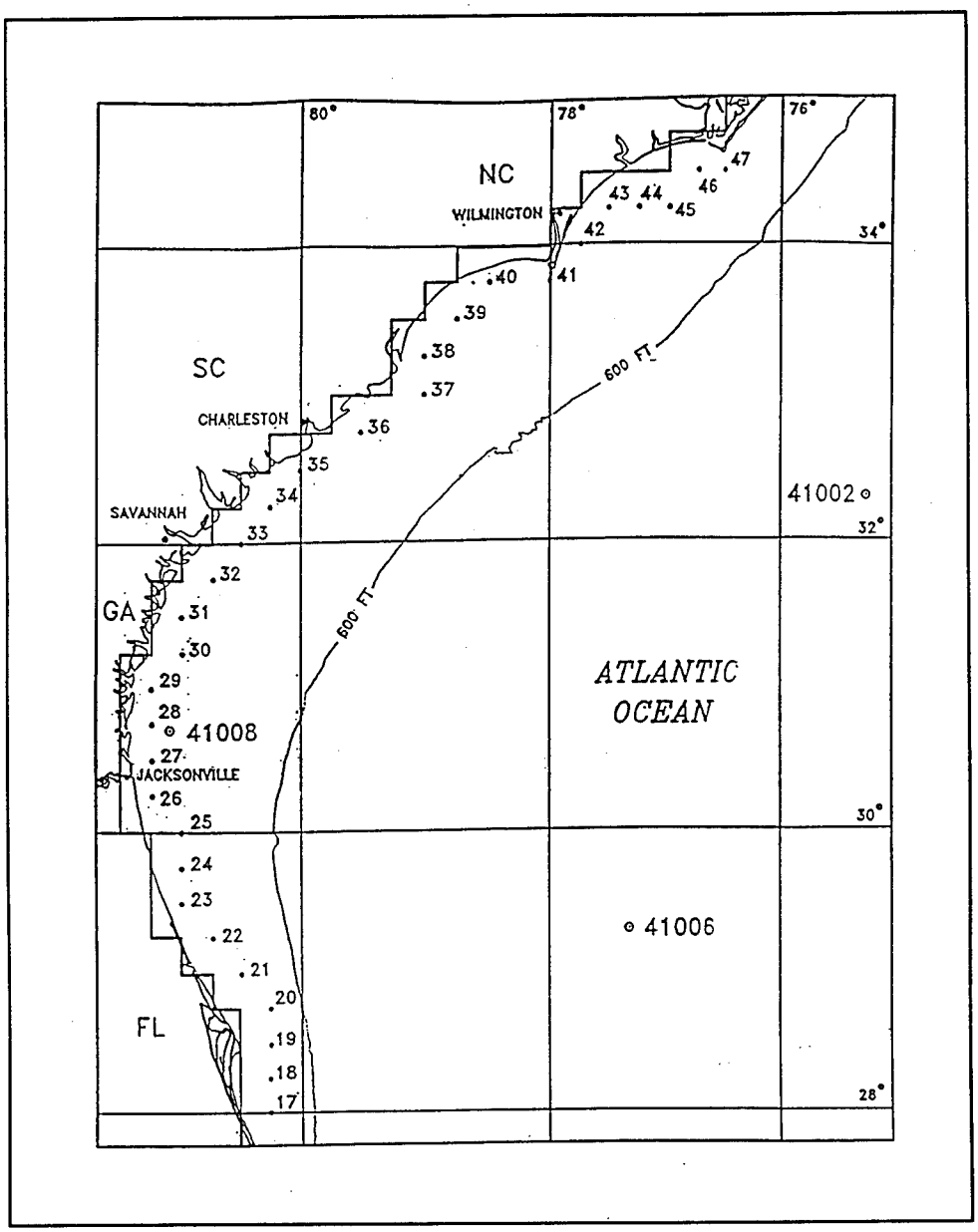


Figure 3. (Sheet 2 of 4)

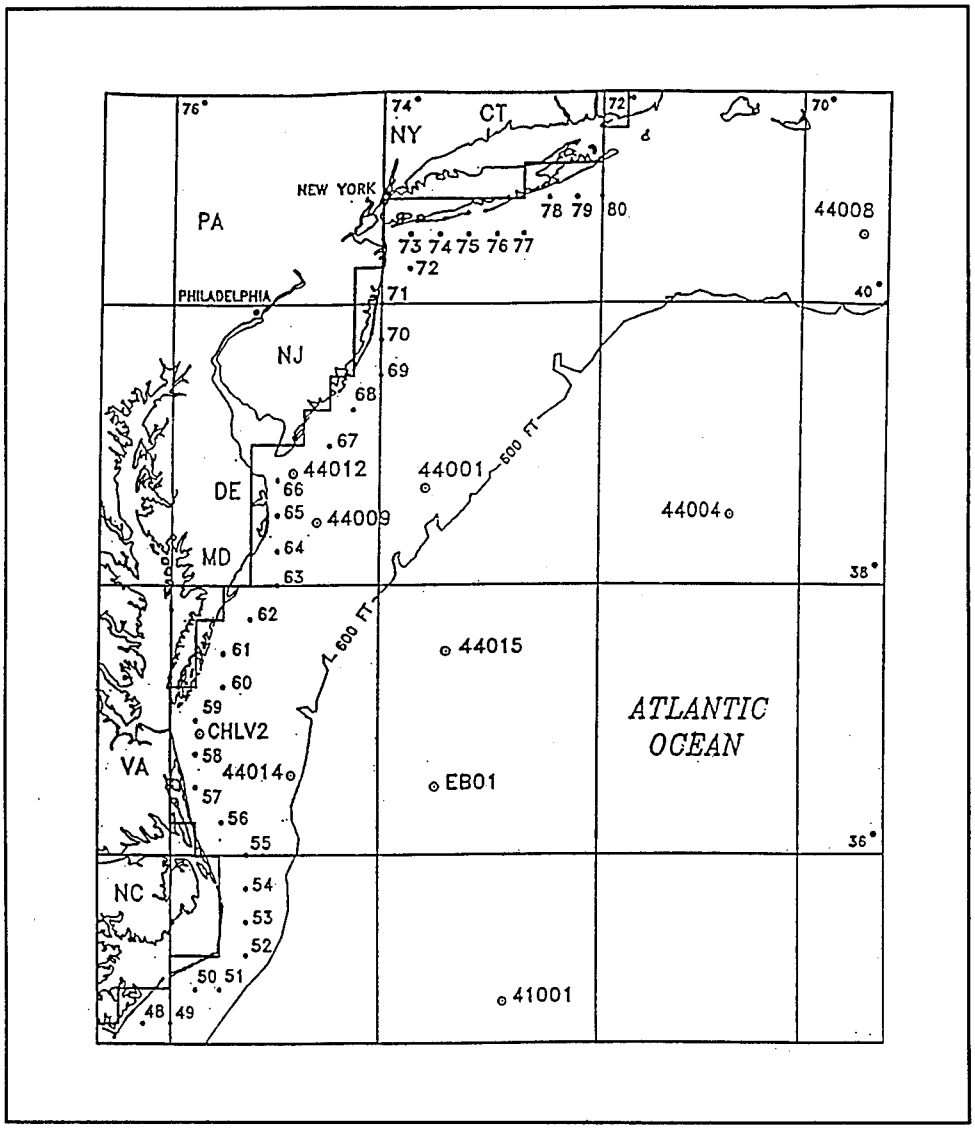


Figure 3. (Sheet 3 of 4)

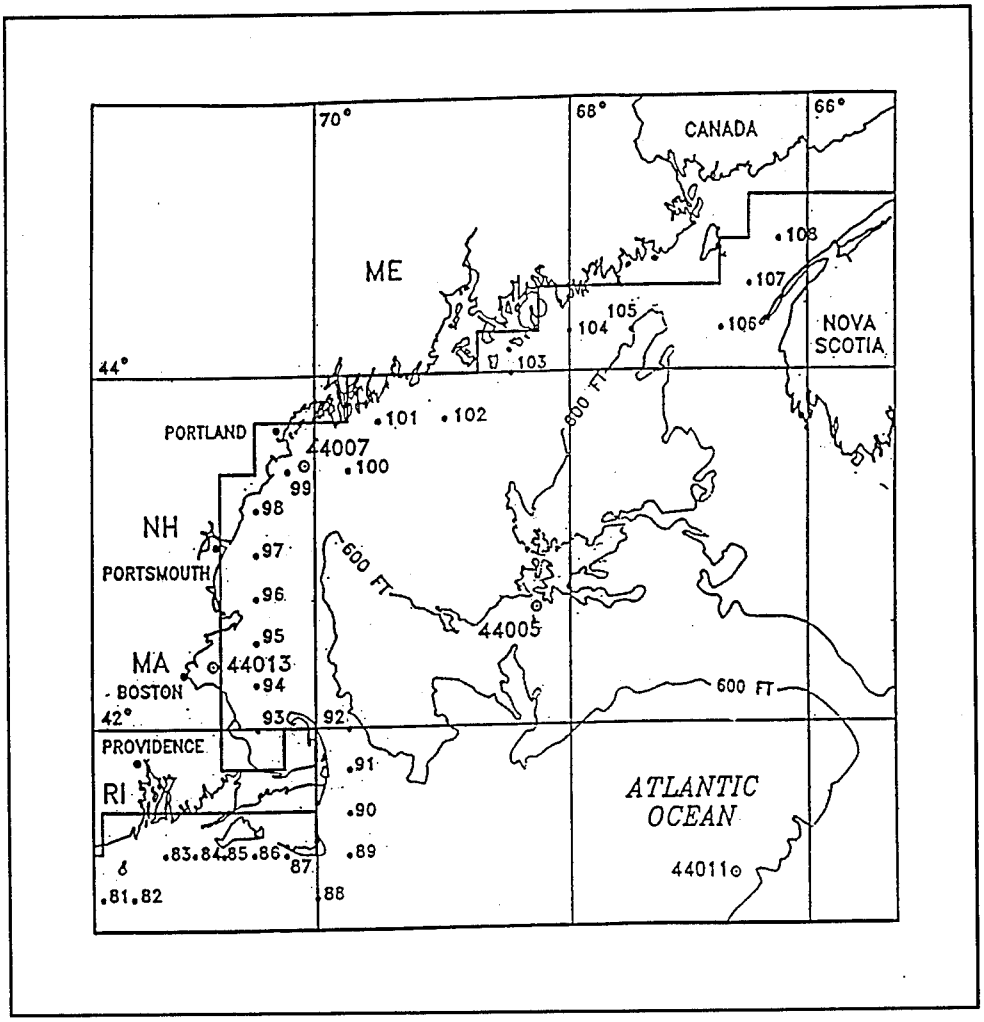


Figure 3. (Sheet 4 of 4)

2 Weather Events Description

The 1994 hurricane season produced one hurricane that affected the U.S. Atlantic coastal stations. Hurricane Gordon moved on an unusual path from November 8 to November 21. See Figure 4 for Gordon's track. The storm first moved over the Caribbean area into the Gulf of Mexico. The storm next moved over the west coast of Florida, across Florida, and turned northeast toward the Atlantic. On November 16, Gordon moved into the Atlantic north of Vero Beach, FL. On November 18, the storm looped and backtracked (see Figure 4), threatening the North Carolina coastline. The NMC winds have a good representation of Gordon in the Atlantic level 1 winds. A preliminary hindcast using the interpolated level 2 NMC winds showed underprediction in the wave heights near the Florida coast. A new level 2 wind field was needed to produce a more accurate hurricane hindcast so the data in the preliminary report from the National Hurricane Center (Pasch 1995) were used in the HURWIN process described in WIS 33 (Brooks and Brandon 1995) to create a hurricane wind field for Gordon. These hurricane winds were calculated at 1-hr intervals and were written to the 0.25-deg, level 2 grid. These new hurricane wind fields were then blended into the NMC Atlantic level 2 wind fields to produce a better definition of Hurricane Gordon. Figure 5 shows a representative comparison with NOAA buoy 41006 for the month of November at one of the stations close to Gordon's path. Figure 5 shows comparisons of significant wave height *Hs*, peak period *Tp*, wind speed *Ws*, and wind direction *Wd*. Wind direction is in the meteorological convention. Hurricane Gordon moved near this buoy on November 17 and produced the wind speed and significant wave height peak shown in Figure 5. Chapter 3 contains a discussion of the statistics for this monthly plot and the other verification locations.

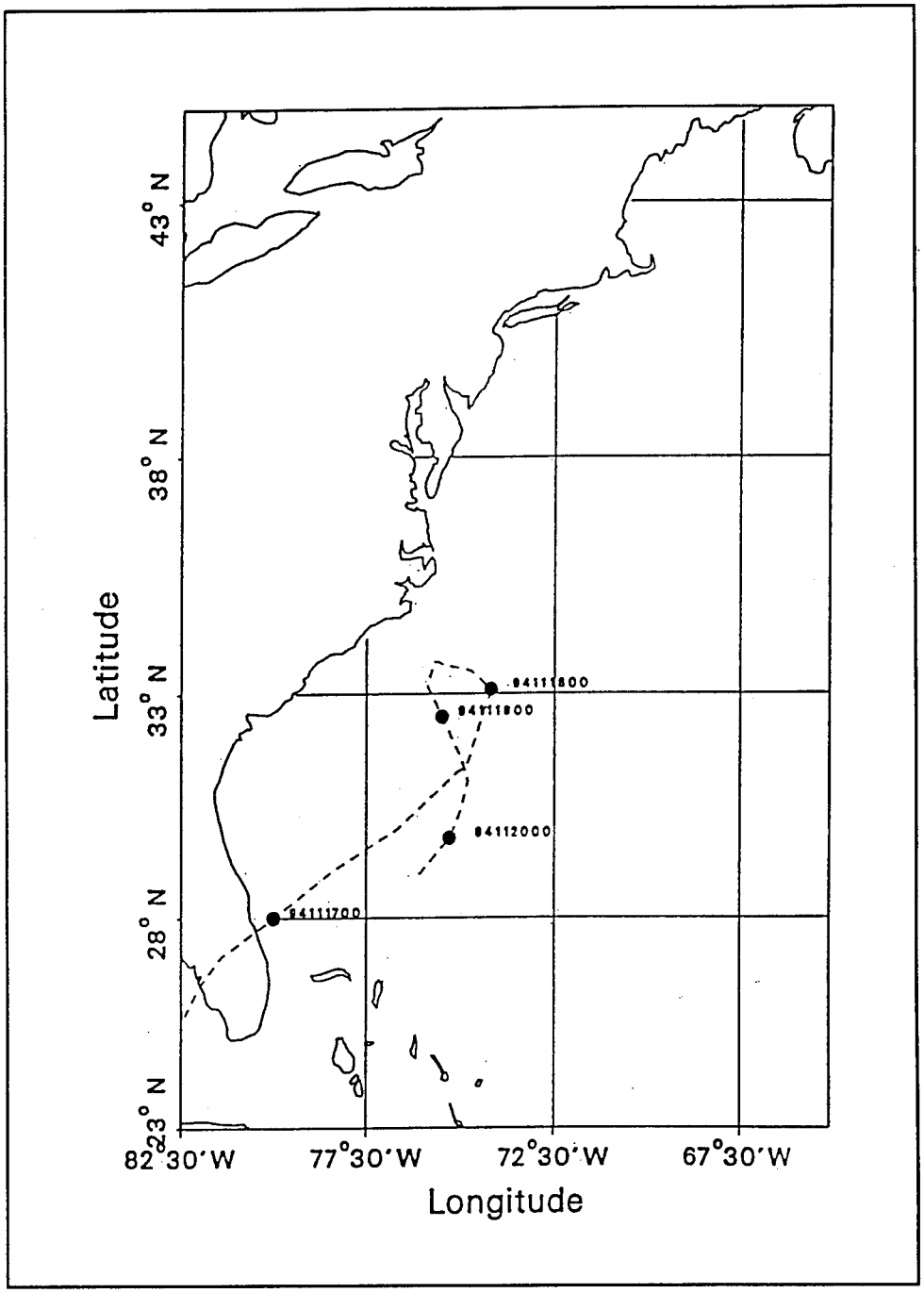


Figure 4. Hurricane Gordon track

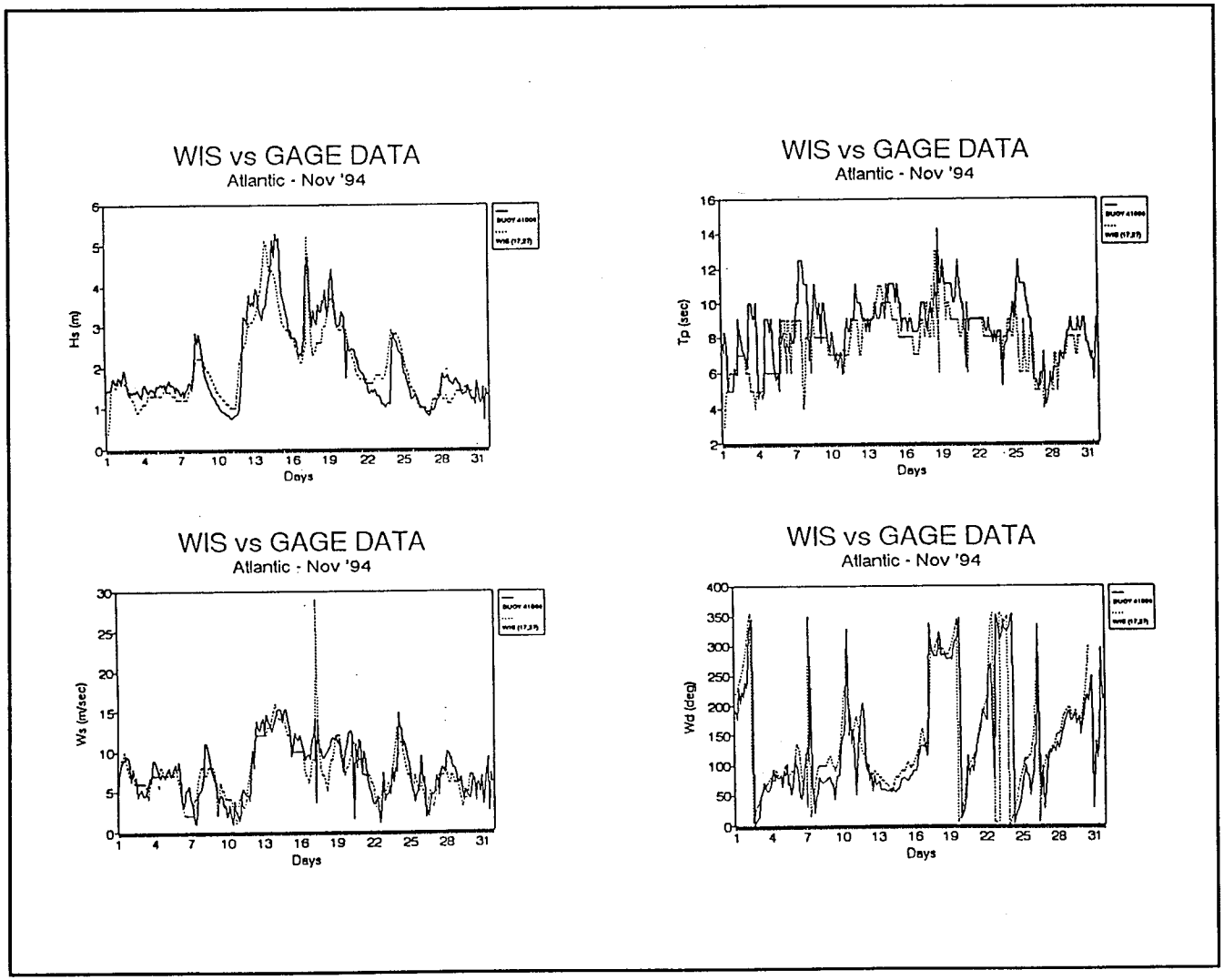


Figure 5. Hurricane Gordon wave comparison. Buoy 41006 is located off the Florida coast at 29.3° latitude, 77.4° longitude

3 Verification of Model Results

Wind and wave data from the 16 National Oceanic and Atmospheric Administration (NOAA) wave gauges shown in Figure 6 were compared to the closest WIS stations. Table 1 lists the buoy depth, buoy location, and the corresponding WIS station used for comparison. Comparisons were done each month and included 13 to 15 buoys each month. Figure 7 shows a representative comparison plot for NOAA buoy 44013 and the corresponding WIS station for January 1994. This figure contains separate plots for significant wave height *Hs*, peak period *Tp*, peak mean wave direction *Dp*, wind speed *Ws*, and a wind direction *Wd* comparison. Directions are in the meteorological convention.

Monthly tables of statistics describing the means from the 1994 monthly plots are shown in Tables 2 through 13. The bias, the root mean square difference (RMSD), and the number of cases used for comparison are listed in these tables. RMSD values for the hindcast and the measured data were calculated by summing the square of the difference between the two for each time period, then taking the square root of the total and dividing it by the number of records used. The bias for each month was calculated by subtracting the monthly buoy mean from the monthly WIS mean. A positive bias indicates the WIS value is higher than the measured value. The statistics describing the plots shown in Figure 7 are listed in the first row of the January statistics table (Table 2). The wave height bias is +0.1 m, and the peak period bias is -0.7 sec. The wave height and peak period bias indicate very good agreement with the measured data. The wave direction shows a bias of 23.5 deg. The *Dp* plot in Figure 7 shows generally good agreement on the wave direction; but the measured direction differs from the calculated direction in times of low wave energy. The wind speed *Ws* bias indicates good agreement with a bias of +0.9 m/sec. The wind direction *Wd* bias is 3.9 deg. The wind direction may show some variation since it is an interpolated direction, but a bias of 3.9 deg indicates good agreement. The other measurement sites that have the capability to measure wave direction show better wave direction agreement. Buoy 44013 is very close to the coast near the Boston, MA, harbor entrance (see Figure 3 for location), and the numerical wave model grid may not reflect all the features contributing to the wave direction at 44013.

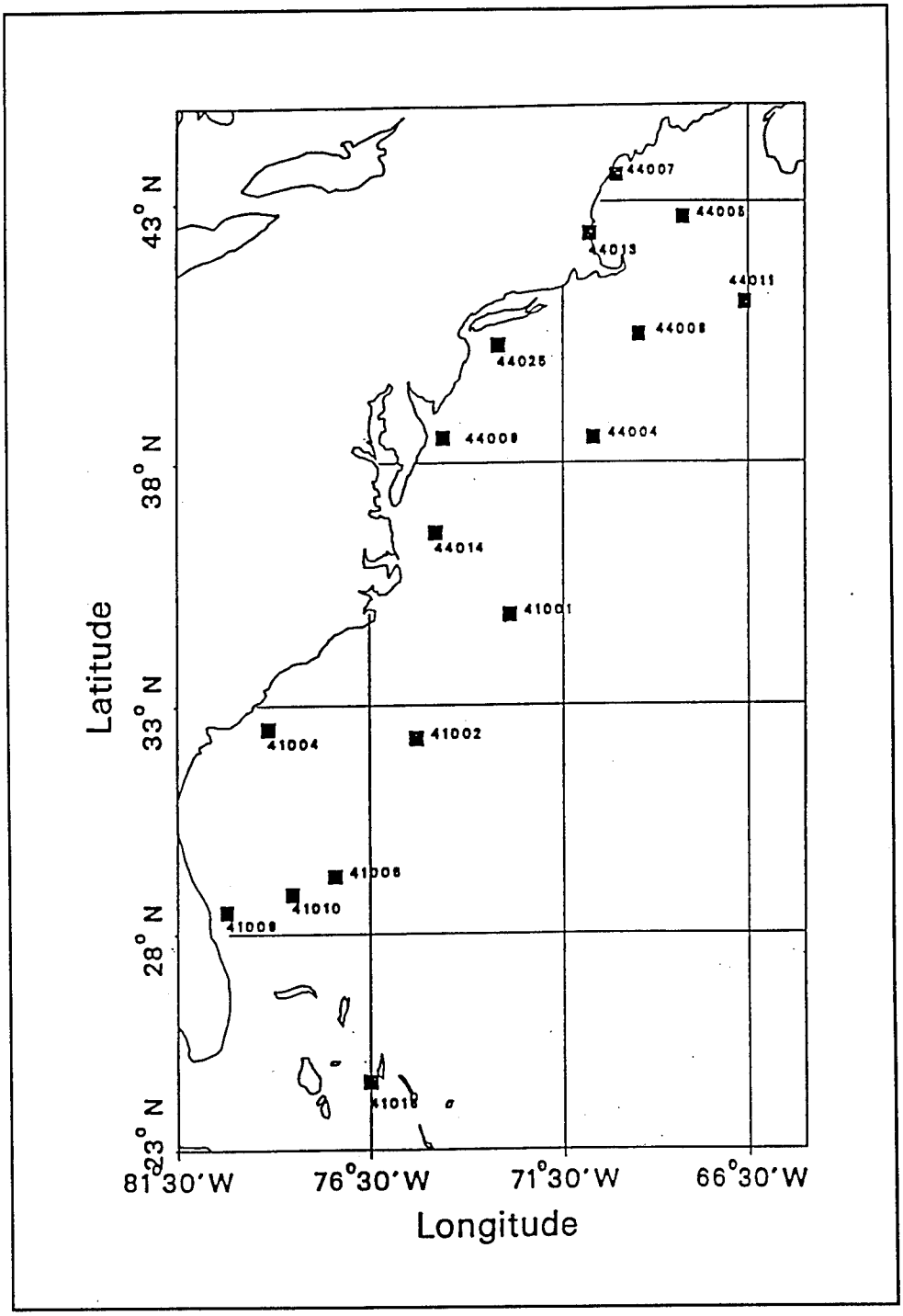


Figure 6. NOAA buoy locations on level 2 Atlantic grid

Table 1
Buoy Locations

Buoy	WIS Station	Latitude	Longitude	Depth (m)
41001	128	34.9	73.0	4444
41002	131	32.3	75.2	3658
41004	130	32.5	79.1	37
41006	137	29.3	77.4	1042
41009	19	28.5	80.2	42
41010	138	28.9	78.5	860
41016	139	24.6	76.5	1586
44004	121	38.5	70.7	3231
44005	111	42.6	68.6	202
44007	109	43.5	70.1	47
44008	115	40.5	69.5	60
44009	119	38.5	74.6	28
44011	113	41.1	66.6	87
44013	94	42.4	70.8	30
44014	124	36.6	74.8	48
44025	116	40.3	73.2	40

Two comparison locations, Buoys 41016 and 44014, consistently show a wave height bias greater than +0.2 m in Tables 2 through 13. Buoy 41016, in the Bahamas, is closer to the island and shows more island sheltering than the related WIS station. The WIS station that compares to 44014 is in deeper water farther offshore than 44014, so it shows higher wave heights than the buoy location.

The bar charts in Figures 8 through 19 display the mean significant wave height and the mean peak period from the monthly plots (similar to Figure 7) for each gauge-WIS station set. The WIS mean is shown as an empty bar, and the gauge mean is shown with cross-bar shading.

Figure 20 shows the bar charts relating the yearly mean significant wave heights and the yearly mean peak periods for each of the comparison locations. Table 14 lists the statistics related to these yearly means. Table 14 has the same format as Tables 2-13. The average wave height bias for the year is +0.10 m, and the average peak period bias for the year is -0.54 sec. Positive numbers indicate that the WIS parameter is higher than the gauge. These statistics indicate that the WIS wave heights run slightly high and the WIS peak periods

are slightly low. These statistics show good agreement between the WIS hindcast wave heights and peak periods and the measured data. The wave direction bias averages 17.25 deg. The average wind speed bias is +0.61 m/sec, and the average wind direction bias is +12.0 deg. The wind speeds are very close to the measured data. The average wind direction bias and the average wave direction bias are very close. Since the input wind direction has a 12.0-deg bias, the output wave direction will reflect this difference.

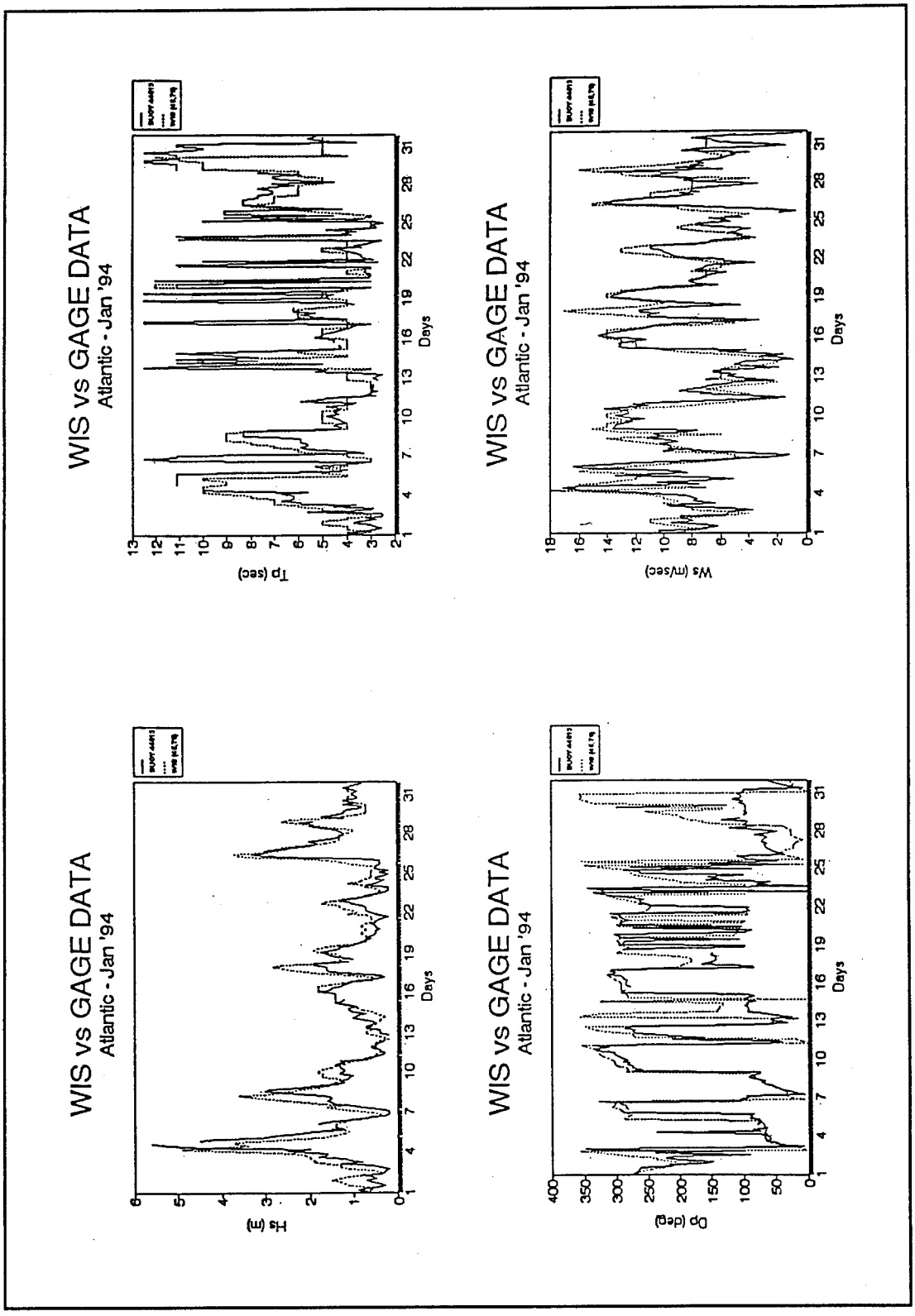


Figure 7. Comparison plot for January using Buoy 44013 (example) (Continued)

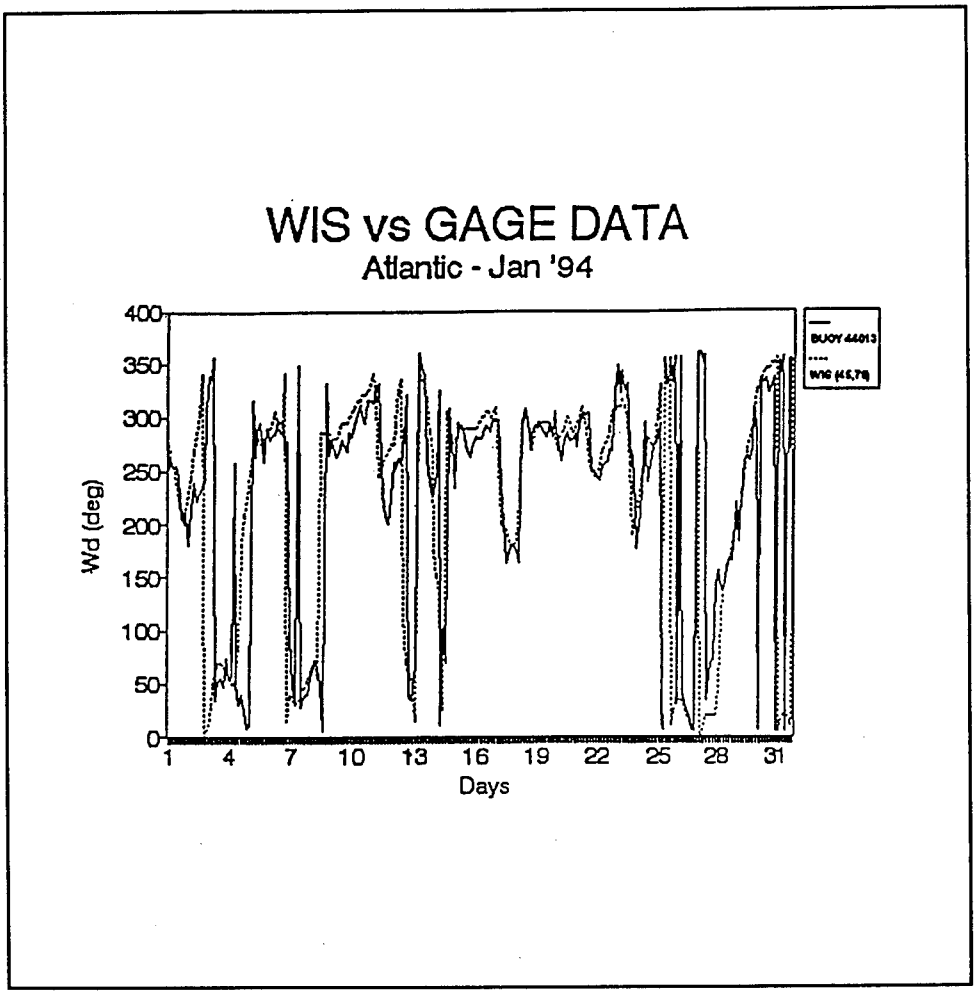


Figure 7. (Concluded)

Table 2
Atlantic Ocean, January

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
44013	94	.1	.5	239	-.7	2.5	239	23.5	76.3	239	.9	2.7	245	3.9	41.6	243
44014	124	.0	.7	71	-.5	2.0	71	16.8	63.0	71	.8	2.4	43	3.8	40.9	43
44025	116	-.1	.6	245	-.3	1.8	245	2.2	67.6	245	-.6	2.2	246	10.9	48.2	241
41009	19	.1	.4	186	-.4	1.3	186	-.8	49.1	185	-1.1	2.5	246	4.5	37.9	244
41004	130	.3	.7	230	-.1	1.4	230	18.8	57.3	227	1.7	3.7	69	24.2	57.9	68
41002	131	.1	.8	246	-.2	1.6	246	.0	.0	0	1.3	2.6	72	13.7	42.8	70
41006	137	.1	.6	231	.0	1.3	231	.0	.0	0	.7	1.9	231	18.3	37.9	230
41010	138	.1	.6	247	.1	1.3	247	.0	.0	0	.7	2.2	248	13.9	39.4	245
41016	139	.4	.6	246	.5	1.4	246	.0	.0	0	-.5	1.7	246	1.2	25.5	244
44008	115	.1	.8	247	-.3	1.3	247	.0	.0	0	.3	2.6	247	.0	33.0	243
44011	113	-.2	.8	160	-.3	1.2	160	.0	.0	0	1.1	3.0	161	3.7	34.4	152
41001	128	.0	.9	247	-.2	1.6	247	.0	.0	0	.8	2.7	248	2.1	43.6	242
44004	121	-.2	.9	247	-.2	1.2	247	.0	.0	0	.6	2.7	247	4.5	37.4	244

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 248 possible.

Table 3
Atlantic Ocean, February

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
44013	94	.2	.6	209	-.7	2.5	209	22.9	80.8	207	.8	2.7	208	15.9	47.1	207
44014	124	.6	.9	131	-.3	1.4	131	35.5	76.5	131	2.4	3.9	216	27.6	56.9	215
44025	116	-.1	.5	216	-.9	2.2	216	19.6	73.3	214	-.4	3.1	218	23.9	54.9	217
14004	130	.2	.6	209	-.6	1.7	209	12.3	62.7	209	.0	.0	0	.0	.0	0
41009	19	.1	.4	109	-.3	1.2	109	-1.8	33.3	109	-1.1	2.3	220	2.6	41.3	213
44009	119	.0	.0	0	.0	.0	0	.0	.0	0	.9	2.9	218	28.4	60.7	215
41002	131	.1	.5	219	-.4	1.4	219	.0	.0	0	.5	1.8	160	15.7	53.4	155
41006	137	.0	.5	185	-.5	1.4	185	.0	.0	0	.4	1.7	188	19.0	37.6	185
41010	138	.2	.4	218	-.4	1.3	218	.0	.0	0	.8	2.0	220	10.5	41.1	216
41016	139	.3	.5	216	.4	1.8	216	.0	.0	0	.1	1.7	220	-4.7	38.7	218
44008	115	.2	.8	218	-.8	2.1	218	.0	.0	0	.1	3.5	198	7.1	37.3	194
44011	113	-.1	.8	217	-.2	1.5	217	.0	.0	0	1.0	3.1	219	15.4	38.0	216
41001	128	-.1	.6	218	-.4	1.4	218	.0	.0	0	.6	2.4	219	15.5	46.3	217
44007	109	.1	.6	179	-1.0	2.5	179	.0	.0	0	.1	2.6	180	12.4	44.8	178
44004	121	-.1	.8	217	-.1	1.8	217	.0	.0	0	.6	3.1	220	12.2	42.8	217

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 224 possible.

Table 4
Atlantic Ocean, March

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
44013	94	.1	.5	248	-1.0	2.9	248	20.5	71.6	244	.8	2.7	248	22.9	55.8	242
44025	116	.2	.5	244	-.2	1.9	244	22.9	59.4	244	.1	2.5	248	19.8	47.1	244
41004	130	.3	.6	238	-.3	1.9	238	24.3	70.0	237	.0	.0	0	.0	.0	0
41009	19	.1	.3	149	-.7	1.9	149	-.3	60.5	147	-.8	2.3	247	19.8	52.5	244
41002	131	.1	.9	248	-.2	1.8	248	.0	.0	0	1.2	2.3	248	17.9	34.2	246
41006	137	.2	.5	246	-.1	1.4	246	.0	.0	0	.7	1.8	248	17.1	36.6	247
41010	138	.2	.6	247	-.2	1.5	247	.0	.0	0	.8	2.2	247	10.1	37.5	244
41016	139	.3	.4	202	.2	1.1	202	.0	.0	0	-.1	1.6	246	-4.6	39.6	247
44008	115	.3	.8	246	-.2	1.3	246	.0	.0	0	.0	.0	0	.0	.0	0
44011	113	.0	.9	206	-.2	1.2	206	.0	.0	0	2.1	3.6	207	12.7	51.3	204
41001	128	.0	1.0	244	-.1	1.5	244	.0	.0	0	1.5	3.0	246	6.4	39.3	241
44007	109	.0	.4	240	-1.0	3.2	240	.0	.0	0	.1	2.5	245	16.6	56.1	241
44004	121	.0	.9	245	.0	1.2	245	.0	.0	0	1.1	2.7	246	6.6	45.0	244

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 248 possible.

Table 5
Atlantic Ocean, April

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
44013	94	.2	.4	231	-.9	2.6	231	36.4	86.0	220	.8	2.4	239	26.0	57.5	239
44025	116	.0	.4	236	-.1	1.4	236	11.1	49.6	236	-.4	2.4	234	26.7	60.6	234
41004	130	.2	.4	230	-.6	1.2	230	9.5	39.3	230	.9	1.9	30	16.1	57.5	30
41009	19	.2	.4	221	-.3	1.4	221	5.2	28.9	221	-.3	2.4	64	-14.1	93.5	64
41002	131	.1	.4	239	-.2	1.4	239	.0	.0	0	.4	1.9	239	10.0	44.3	237
41006	137	.1	.3	236	-.4	1.2	236	.0	.0	0	.2	1.4	235	16.1	37.9	232
41010	138	.1	.3	238	-.2	1.1	238	.0	.0	0	.1	1.8	238	9.6	36.5	237
41016	139	.3	.5	237	.1	1.3	237	.0	.0	0	-.2	1.5	239	-6.2	23.7	238
44008	115	.3	.5	232	-.5	1.8	232	.0	.0	0	.9	2.1	151	13.8	40.6	151
44011	113	.2	.5	237	-.1	1.3	237	.0	.0	0	2.1	3.1	237	21.1	46.4	235
44007	109	.0	.4	235	-.5	2.0	235	.0	.0	0	-.6	2.9	234	20.4	56.4	233
44004	121	.1	.5	239	.0	1.3	239	.0	.0	0	.9	2.5	239	10.9	38.9	234
44005	111	.2	.5	143	.2	1.4	143	.0	.0	0	1.0	2.5	142	22.7	49.0	143

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 240 possible.

Table 6
Atlantic Ocean, May

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
44013	94	.0	.4	242	-1.4	2.8	242	41.2	80.3	238	.8	2.4	243	16.4	58.1	239
44025	116	.0	.3	240	-.4	1.6	240	-.4	40.4	239	-.1	2.0	239	10.7	49.3	237
41004	130	.2	.5	242	-.5	1.4	242	6.6	52.9	241	.8	2.4	242	9.8	51.6	238
41009	19	.2	.4	236	-.4	1.5	236	2.0	29.2	236	-.1	2.3	164	-10.1	58.1	160
44014	124	.3	.6	242	-.3	1.6	242	17.0	53.2	241	1.6	2.8	242	10.5	56.4	239
41002	131	.1	.4	246	-.4	1.2	246	.0	.0	0	.4	2.0	246	3.5	45.1	240
41006	137	.1	.4	244	-.6	1.2	244	.0	.0	0	.0	2.1	244	18.3	53.4	242
41010	138	.1	.5	245	-.5	1.4	245	.0	.0	0	.4	2.4	245	4.8	54.9	242
41016	139	.2	.3	197	-.1	1.4	197	.0	.0	0	.1	1.7	245	-1.2	42.7	244
44008	115	-.1	.7	246	-.8	1.6	246	.0	.0	0	1.7	3.3	246	23.9	61.2	242
44011	113	.1	.5	246	-.3	1.1	246	.0	.0	0	1.7	2.7	245	12.2	42.8	245
44007	109	.0	.4	245	-.6	1.9	245	.0	.0	0	.3	2.3	245	13.7	60.1	244
44004	121	.0	.5	246	-.4	1.3	246	.0	.0	0	1.1	2.5	245	17.2	40.2	243
44005	111	.3	.6	245	.0	1.5	245	.0	.0	0	.8	2.6	243	13.5	41.3	244
41001	128	.0	.5	243	-.1	1.3	243	.0	.0	0	.5	2.1	243	9.5	41.2	239

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 248 possible.

Table 7
Atlantic Ocean, June

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
44013	94	.2	.4	237	-1.6	3.0	237	63.7	90.8	229	.6	1.8	139	19.1	52.4	139
44025	116	.1	.3	234	-.6	1.5	234	17.4	41.8	234	-.6	1.9	232	17.6	43.5	231
41009	19	.2	.2	233	-1.0	1.6	232	-4.9	47.2	230	-.3	1.9	231	-11.4	64.0	231
44014	124	.3	.6	238	-.5	1.6	238	5.1	43.8	238	1.0	2.2	238	10.9	44.7	237
41002	131	.0	.2	237	-.7	1.4	237	.0	.0	0	.1	1.5	237	6.6	39.5	236
41006	137	.0	.2	237	-.9	1.5	237	.0	.0	0	-.1	1.5	237	5.9	47.4	236
41010	138	.0	.2	239	-1.1	1.7	239	.0	.0	0	.2	1.5	238	4.7	53.7	239
41016	139	.1	.2	206	.0	1.0	206	.0	.0	0	-.1	1.4	238	-8.7	40.2	238
44008	115	.2	.4	240	-1.0	1.8	240	.0	.0	0	1.7	2.3	239	24.3	39.7	237
44011	113	.1	.4	239	-.6	1.6	239	.0	.0	0	1.7	2.4	238	24.4	50.6	238
44007	109	-.1	.2	239	-.7	2.0	239	.0	.0	0	.5	1.9	238	31.5	61.9	237
44004	121	.1	.3	214	-.7	1.7	214	.0	.0	0	.0	2.0	214	5.1	36.7	214
44005	111	.3	.4	240	.0	1.5	240	.0	.0	0	.8	1.8	224	19.7	43.6	224
41001	128	.0	.2	238	-.5	1.5	238	.0	.0	0	.5	1.5	238	14.0	41.0	238

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 240 possible.

Table 8
Atlantic Ocean, July

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
41009	19	.1	.2	243	-1.5	2.0	243	15.5	29.0	242	.0	1.8	229	-2.2	42.4	229
44013	94	.2	.3	233	-2.0	3.2	233	54.1	78.1	226	.0	.0	0	.0	.0	0
44014	124	.3	.4	238	-.8	1.9	238	32.6	45.6	238	.9	1.9	237	7.7	42.3	237
44025	116	.1	.3	235	-.9	1.8	235	10.0	40.1	235	-.2	1.9	230	9.3	55.1	233
41004	130	.1	.3	236	-.8	1.8	236	23.3	43.6	236	.5	2.1	236	2.3	40.7	236
41002	131	-.1	.2	246	-.6	1.2	246	.0	.0	0	.6	1.6	246	5.3	24.5	246
41006	137	.0	.2	238	-1.1	1.7	238	.0	.0	0	.2	1.6	237	3.9	37.4	237
41010	138	.0	.2	244	-1.0	1.7	244	.0	.0	0	.7	2.0	244	.4	44.0	244
41016	139	.2	.3	241	.2	.7	241	.0	.0	0	-.2	1.5	238	-9.7	23.2	241
44004	121	.1	.2	146	-.2	1.1	146	.0	.0	0	.6	1.6	146	-1.4	38.7	145
44008	115	.2	.3	241	-1.1	1.9	241	.0	.0	0	1.6	2.2	241	29.3	52.0	241
44011	113	.0	.3	242	-.9	1.6	242	.0	.0	0	1.4	2.2	242	17.6	42.5	240
44005	111	.2	.4	243	-.4	1.8	243	.0	.0	0	1.1	1.8	33	10.7	29.8	33
44007	109	.0	.2	243	-.9	1.8	243	.0	.0	0	.6	1.9	243	34.1	63.1	242

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 248 possible.

Table 9
Atlantic Ocean, August

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
41004	130	.1	.2	242	-1.0	1.8	242	-2.4	45.8	242	.2	1.7	242	9.4	39.9	241
41009	19	.1	.3	240	-1.5	2.0	239	2.2	19.1	240	-.3	1.8	237	-.5	56.7	235
44013	94	.1	.4	236	-1.4	2.5	236	58.0	91.7	231	.0	.0	0	.0	.0	0
44014	124	.1	.4	246	-.9	1.8	246	19.0	55.2	244	.6	1.8	246	10.8	43.2	244
44025	116	-.1	.3	242	-.6	1.4	241	10.0	35.6	241	.2	1.8	242	10.9	58.3	239
41001	128	.0	.3	73	-.7	1.5	73	.0	.0	0	-.1	1.7	73	-2.6	36.2	72
41002	131	-.1	.2	244	-1.4	2.1	244	.0	.0	0	.5	1.9	244	3.0	48.5	244
41006	137	.0	.2	244	-1.3	1.8	244	.0	.0	0	.0	1.7	244	10.2	42.9	244
41010	138	.0	.3	244	-1.3	2.0	244	.0	.0	0	.3	1.9	244	9.1	54.8	244
41016	139	.1	.3	240	-.4	1.5	240	.0	.0	0	.1	1.8	244	-2.6	27.7	244
44004	121	.0	.3	247	-.6	1.4	247	.0	.0	0	.0	1.6	242	7.8	41.3	240
44008	115	.1	.4	241	-.7	1.4	241	.0	.0	0	1.5	2.4	240	24.6	48.3	238
44011	113	.1	.4	246	-.3	1.1	246	.0	.0	0	1.1	2.0	246	9.8	33.7	243
44005	111	.1	.5	246	-.3	1.8	246	.0	.0	0	1.0	2.5	243	6.8	39.3	241
44007	109	-.1	.3	247	-1.0	2.2	247	.0	.0	0	.4	1.7	247	26.0	60.9	243

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 248 possible.

Table 10
Atlantic Ocean, September

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
41004	130	.0	.3	230	-.8	2.2	230	-4.2	50.2	230	.1	1.9	229	10.2	51.3	229
41009	19	.2	.3	146	-.7	1.9	145	9.2	24.9	145	-.9	1.8	142	8.7	50.8	142
44013	94	.1	.5	222	-1.2	3.4	222	37.8	79.0	193	-.4	1.7	77	35.7	60.3	78
44014	124	.3	.7	222	-.8	2.5	221	13.4	71.1	220	1.2	2.3	222	17.0	40.3	220
44025	116	-.1	.4	232	-.9	2.6	232	17.4	50.0	230	-.3	1.7	231	10.7	40.4	228
44009	119	.0	.4	232	-1.6	3.4	232	21.9	67.1	230	.4	1.5	232	20.7	40.5	229
41002	131	.0	.4	223	-1.0	2.4	223	.0	.0	0	.5	1.9	223	11.4	51.5	223
41006	137	.0	.3	238	-.4	1.7	238	.0	.0	0	-.3	1.9	238	8.9	42.2	237
41010	138	.0	.3	197	-.6	1.6	197	.0	.0	0	.1	1.8	196	12.4	50.6	195
41016	139	.1	.3	229	-.2	1.0	229	.0	.0	0	.1	1.6	232	-7.6	31.6	233
44004	121	.1	.7	218	-.7	2.4	218	.0	.0	0	.6	2.1	218	7.0	28.5	215
44008	115	.3	.7	236	-.9	3.2	236	.0	.0	0	2.0	2.7	236	21.6	44.8	231
44011	113	.0	.6	237	-.4	2.0	237	.0	.0	0	1.1	2.8	237	7.8	38.2	236
44005	111	.2	.6	238	-.8	2.9	238	.0	.0	0	1.2	2.6	238	6.5	35.6	232
44007	109	.1	.4	235	-2.7	4.9	235	.0	.0	0	.3	1.9	237	27.7	56.4	233

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 240 possible.

Table 11
Atlantic Ocean, October

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
41009	19	.0	.3	233	-.5	1.1	233	7.3	28.9	232	-1.0	2.2	224	2.9	46.0	222
44013	94	.1	.4	240	-.5	2.3	240	22.0	72.1	215	.2	2.2	242	17.1	46.2	239
44014	124	.1	.6	244	-.4	1.8	244	1.3	47.0	238	1.1	2.2	244	15.5	48.2	233
44025	116	-.1	.3	240	-.7	2.1	239	5.3	57.3	239	-.3	1.8	239	12.3	43.2	238
44009	119	-.1	.4	235	-.9	2.1	235	7.8	56.3	231	.0	1.7	235	6.4	40.5	225
41002	131	-.1	.6	237	-.5	1.3	237	.0	.0	0	.8	2.2	237	.0	40.4	232
41006	137	-.1	.5	243	-.4	1.4	243	.0	.0	0	-.2	1.9	243	10.7	39.0	239
41010	138	-.3	.7	205	-.5	1.2	205	.0	.0	0	-.1	1.9	204	7.2	44.3	203
41016	139	.3	.3	226	.4	1.3	215	.0	.0	0	.0	1.6	240	-.5	30.5	240
44004	121	.0	.5	147	-.5	2.0	147	.0	.0	0	.7	1.9	147	1.8	25.6	145
44008	115	.0	.6	247	-.8	2.0	247	.0	.0	0	1.5	2.2	247	7.2	33.6	242
44011	113	.0	.6	243	-.5	1.9	243	.0	.0	0	1.4	2.2	242	-.1	36.3	237
44005	111	.2	.6	244	.0	1.8	242	.0	.0	0	1.6	2.6	138	-1.5	31.7	132
44007	109	.1	.4	239	-1.5	3.3	239	.0	.0	0	.5	2.1	138	14.3	39.7	136

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 248 possible.

Table 12
Atlantic Ocean, November

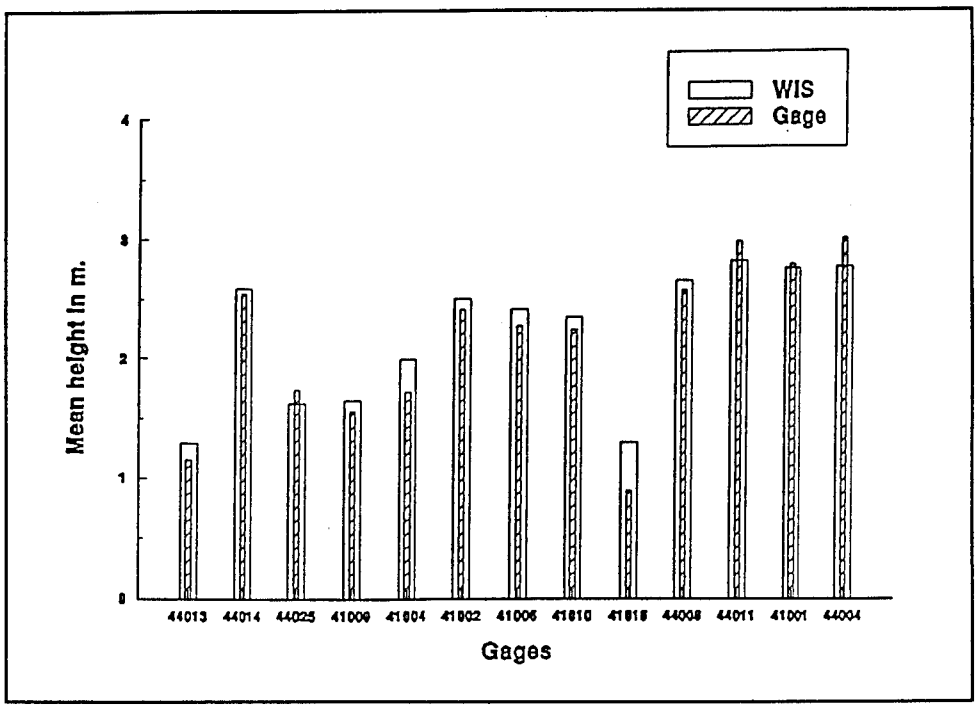
		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
44013	94	.3	.5	235	-1.0	3.1	234	50.6	85.8	221	1.4	2.7	235	32.4	55.1	233
44025	116	.0	.5	218	-.4	1.8	218	14.5	47.9	217	-.2	2.2	217	23.2	39.2	214
44009	119	.2	.5	216	-.6	3.0	216	27.8	54.4	215	.4	2.3	216	25.3	41.6	214
44014	124	.3	.9	232	-.3	1.9	231	16.2	74.2	231	1.2	2.9	231	6.6	41.8	228
41002	131	-.1	.5	208	-.7	1.8	208	.0	.0	0	.5	1.9	208	17.1	39.5	199
41006	137	-.1	.5	235	-.9	2.0	235	.0	.0	0	-.3	2.5	235	15.7	36.5	232
41010	138	-.2	.7	236	-1.0	2.0	236	.0	.0	0	.4	2.0	236	15.5	34.6	234
41016	139	.3	.4	223	.1	1.7	222	.0	.0	0	-.5	1.9	230	-.6	31.1	227
44008	115	.3	.8	232	0	1.6	232	.0	.0	0	2.0	3.0	232	21.4	34.9	230
44011	113	.1	.8	236	0	1.5	235	.0	.0	0	2.3	3.5	236	14.8	35.6	236
44007	109	.2	.5	189	-.8	2.9	188	.0	.0	0	1.4	2.8	121	18.4	52.2	120
44005	111	.4	.8	235	.1	1.8	232	.0	.0	0	1.5	3.0	125	14.0	34.4	122
41001	128	.0	.9	236	-.3	1.7	236	.0	.0	0	.9	2.4	236	10.6	42.2	232

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 240 possible.

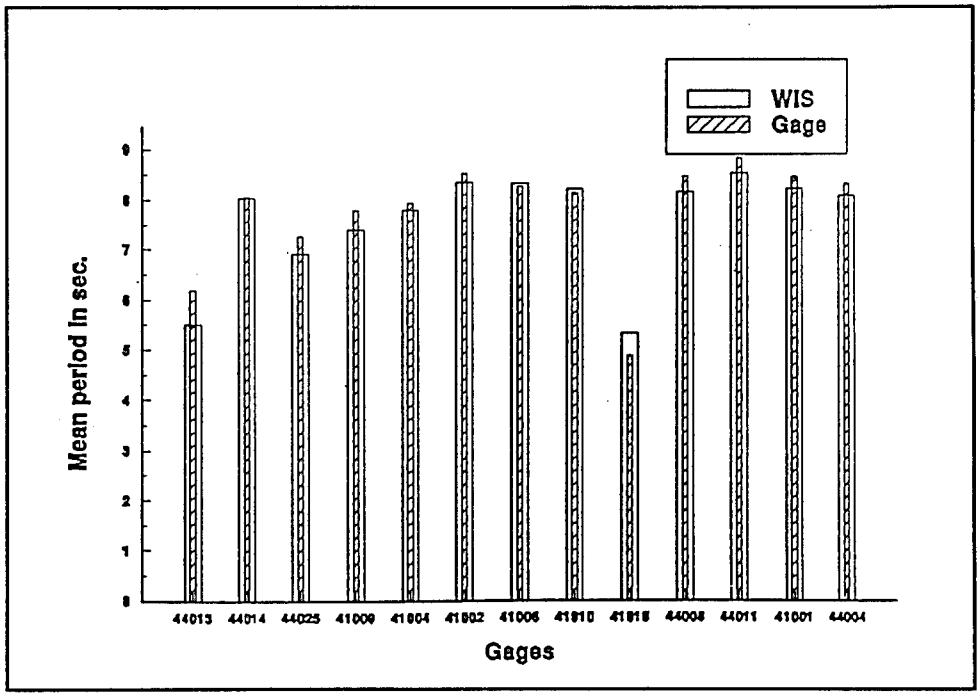
Table 13
Atlantic Ocean, December

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
44013	94	.2	.6	245	-.7	2.5	245	17.6	70.9	231	.9	2.7	246	17.9	57.5	243
44014	124	.4	.9	235	-.3	1.8	234	-44.5	103.1	234	.4	.9	10	-25.5	34.9	10
44025	116	-.1	.6	233	-.8	2.3	233	9.0	63.8	231	-.3	2.0	233	17.0	44.0	229
44009	119	-.1	.6	245	-.4	2.0	245	2.4	56.3	242	.3	2.0	245	14.6	39.8	235
41004	130	.2	.5	240	-.1	1.7	240	3.7	46.5	239	.7	2.7	240	11.9	47.6	236
41009	19	.2	.6	247	-.5	1.3	247	.0	.0	0	-1.1	2.3	247	-9.8	49.7	243
41002	131	.3	.6	161	-.5	1.5	161	.0	.0	0	.7	1.9	161	11.0	39.5	161
41006	137	.2	.6	247	-.5	1.4	247	.0	.0	0	.1	2.2	247	9.9	44.4	245
41010	138	.2	.6	247	-.6	1.7	247	.0	.0	0	.8	2.5	247	18.1	44.9	246
41016	139	.3	.4	207	.1	1.2	202	.0	.0	0	-.5	1.5	207	-2.1	29.6	205
44008	115	-.1	1.0	244	-.5	2.0	244	.0	.0	0	1.7	2.8	60	24.6	36.5	60
44011	113	.1	.8	245	-.1	1.5	245	.0	.0	0	1.8	2.9	197	12.6	38.1	196
41001	128	.2	.8	244	-.3	1.6	244	.0	.0	0	.8	2.5	244	12.3	38.4	240
44005	111	.2	.9	243	.2	1.6	242	.0	.0	0	1.3	2.6	243	9.0	31.3	241
44007	109	.1	.6	182	-.2	2.4	182	.0	.0	0	1.3	2.5	182	18.7	53.8	181

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 248 possible.

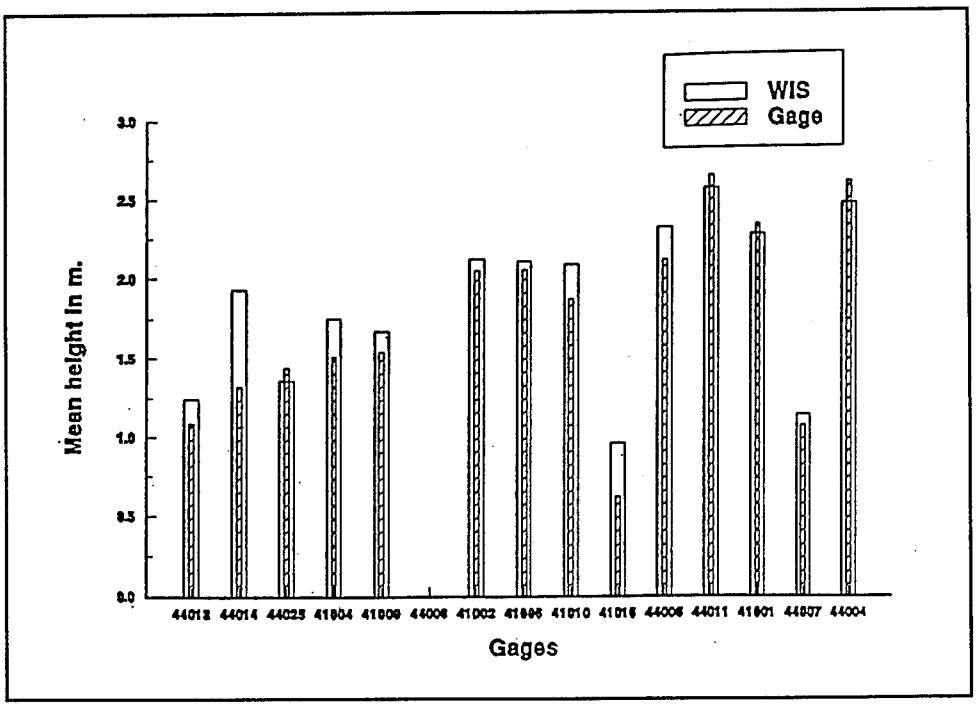


a. Wave height means

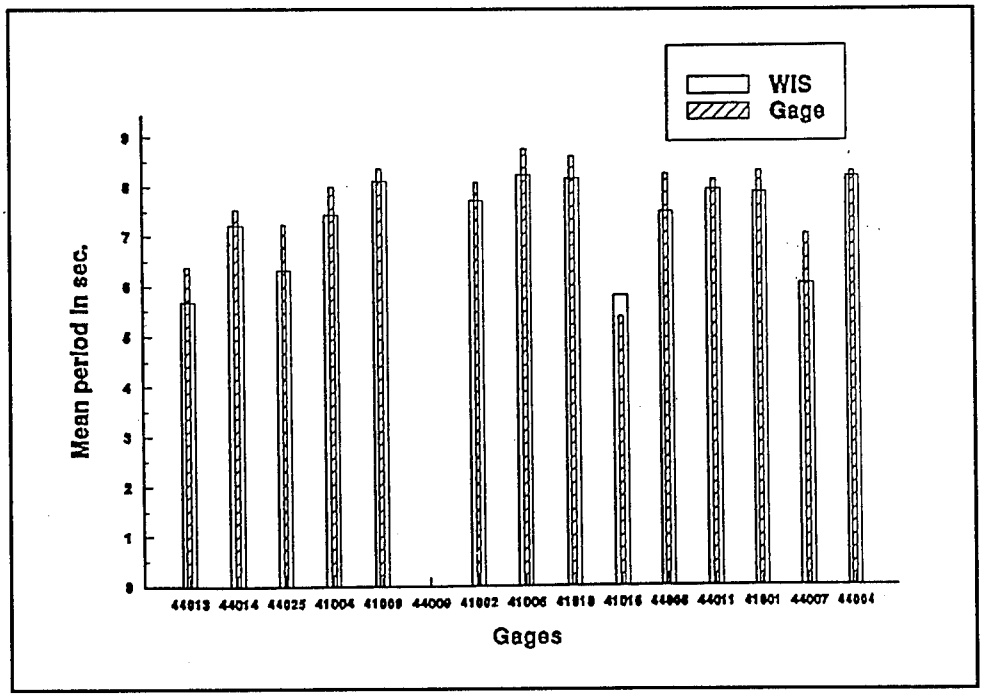


b. Wave period means

Figure 8. Wave information for January 1994

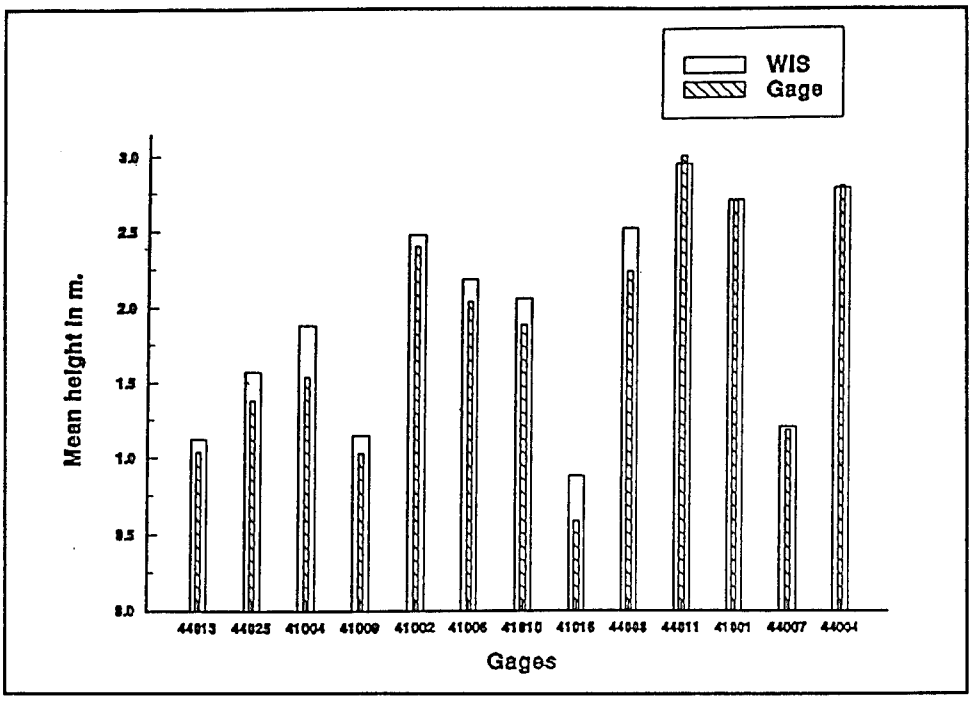


a. Wave height means

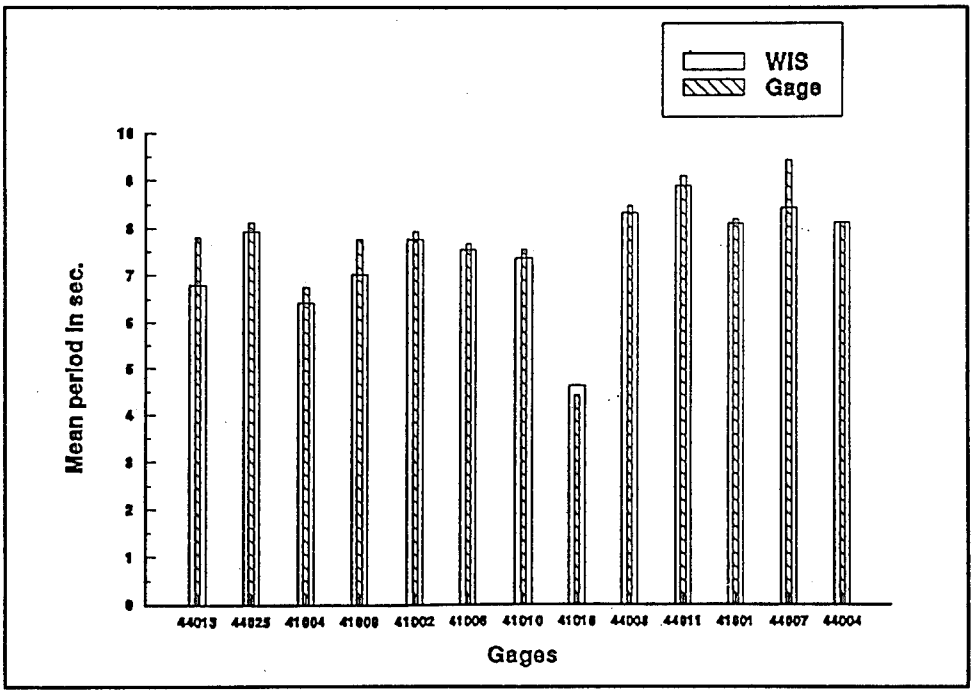


b. Wave period means

Figure 9. Wave information for February 1994

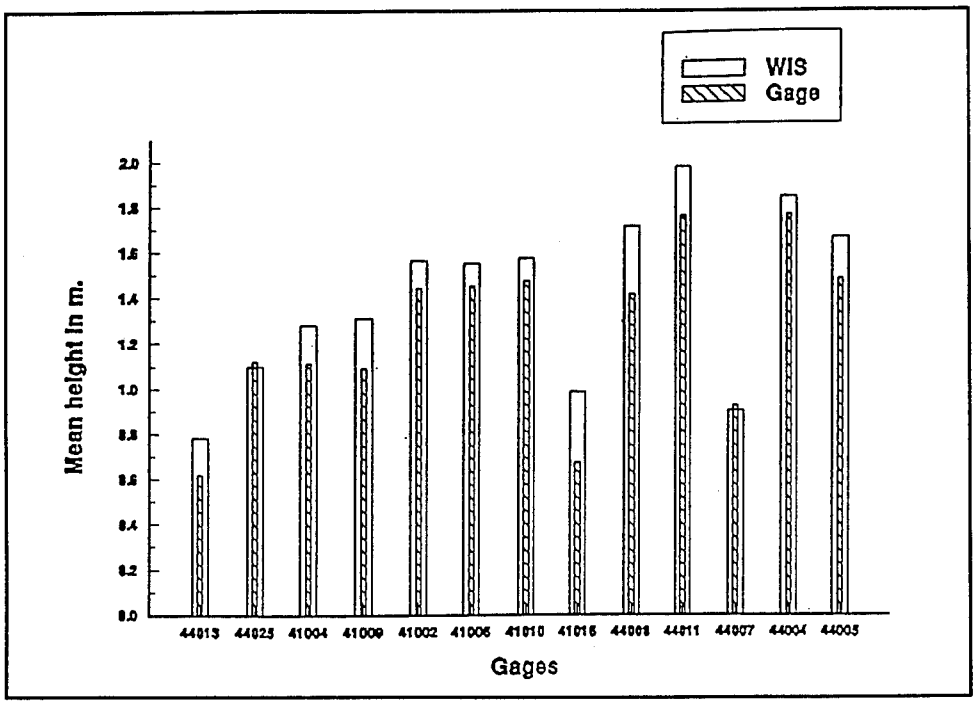


a. Wave height means

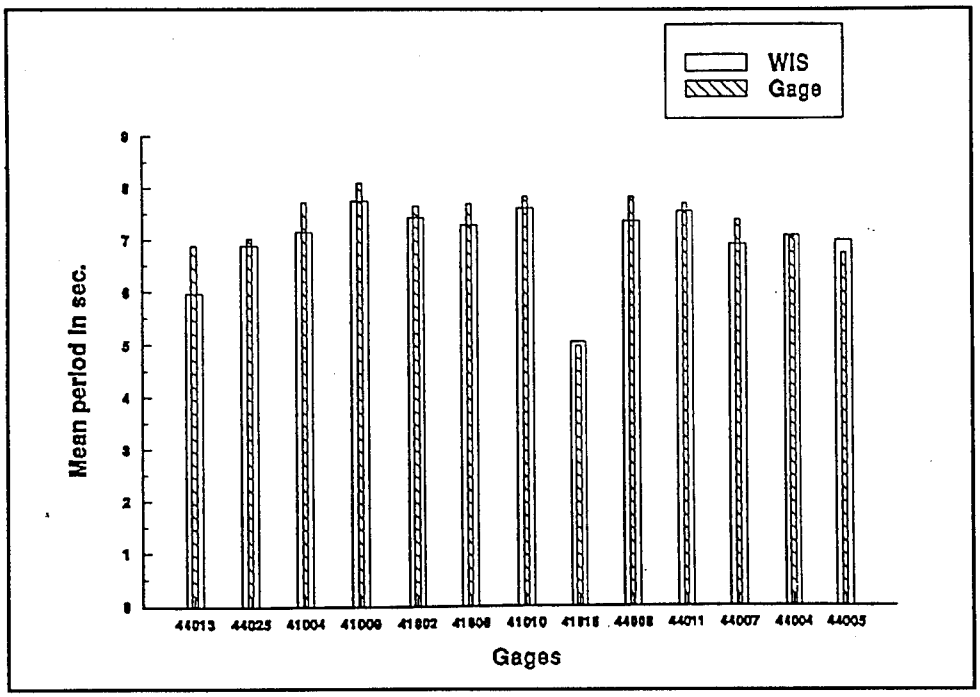


b. Wave period means

Figure 10. Wave information for March 1994

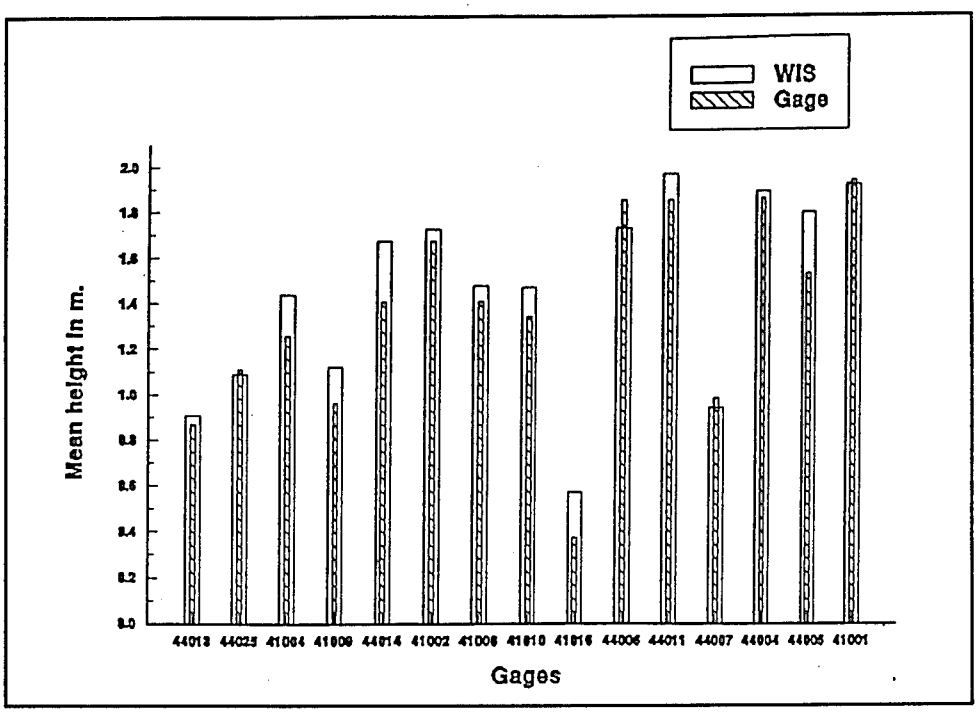


a. Wave height means

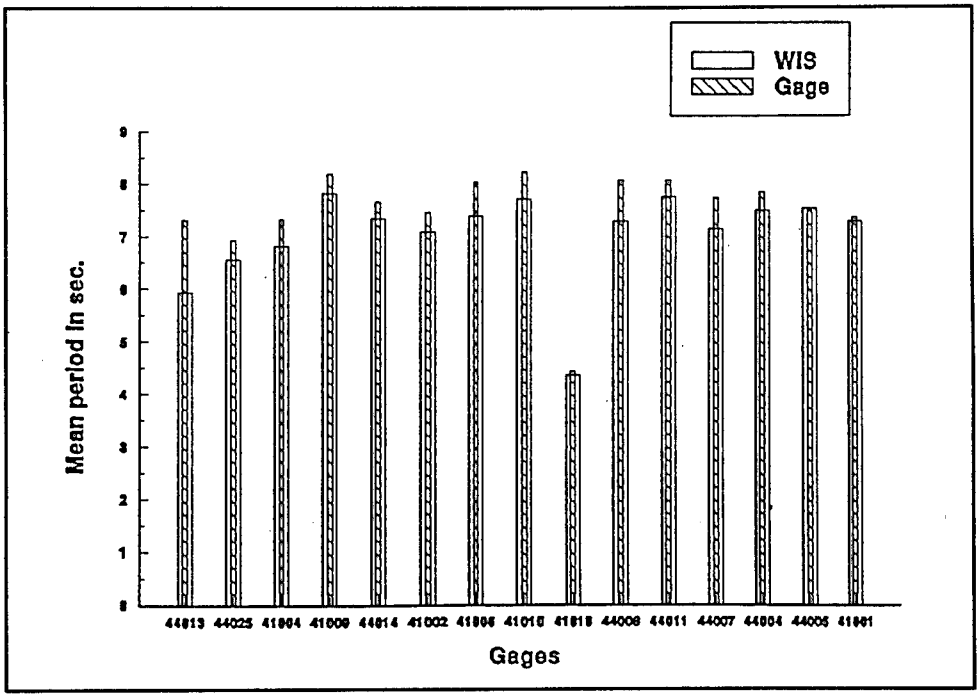


b. Wave period means

Figure 11. Wave information for April 1994

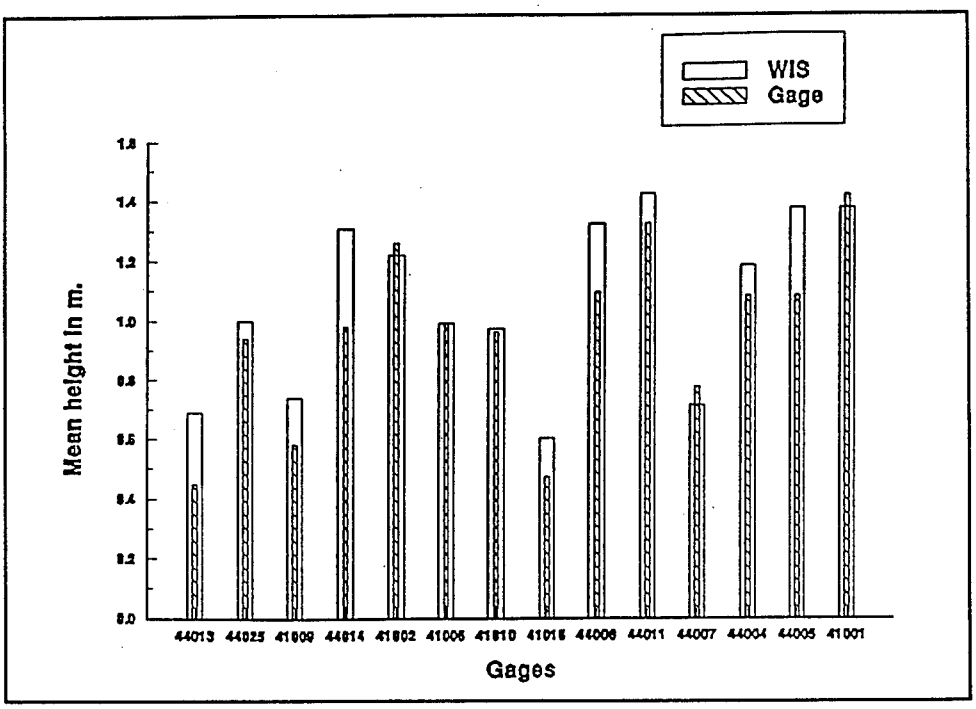


a. Wave height means

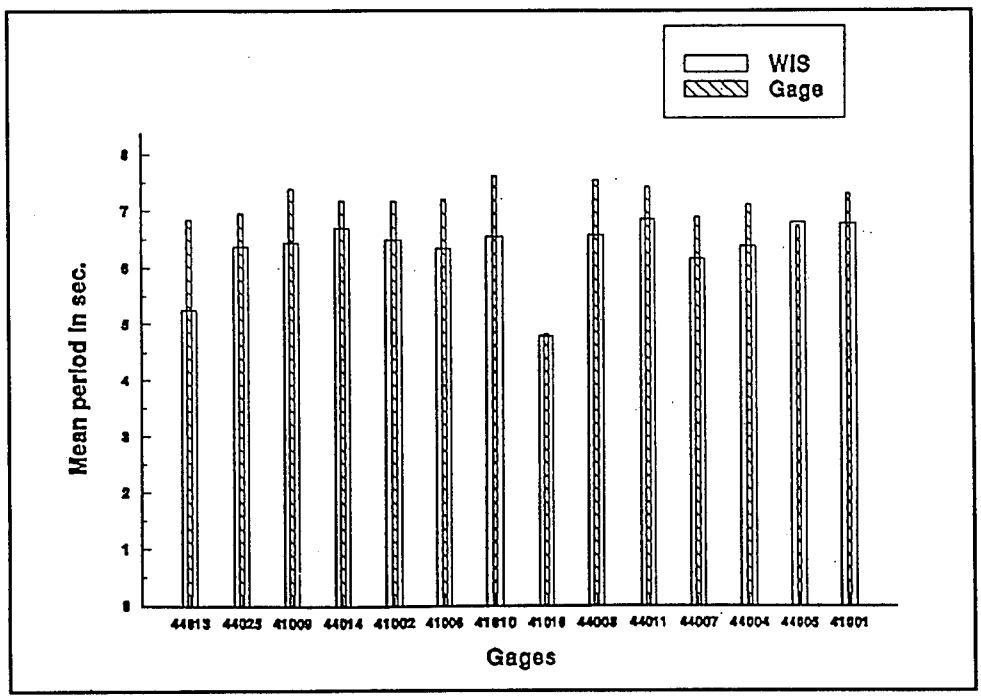


b. Wave period means

Figure 12. Wave information for May 1994

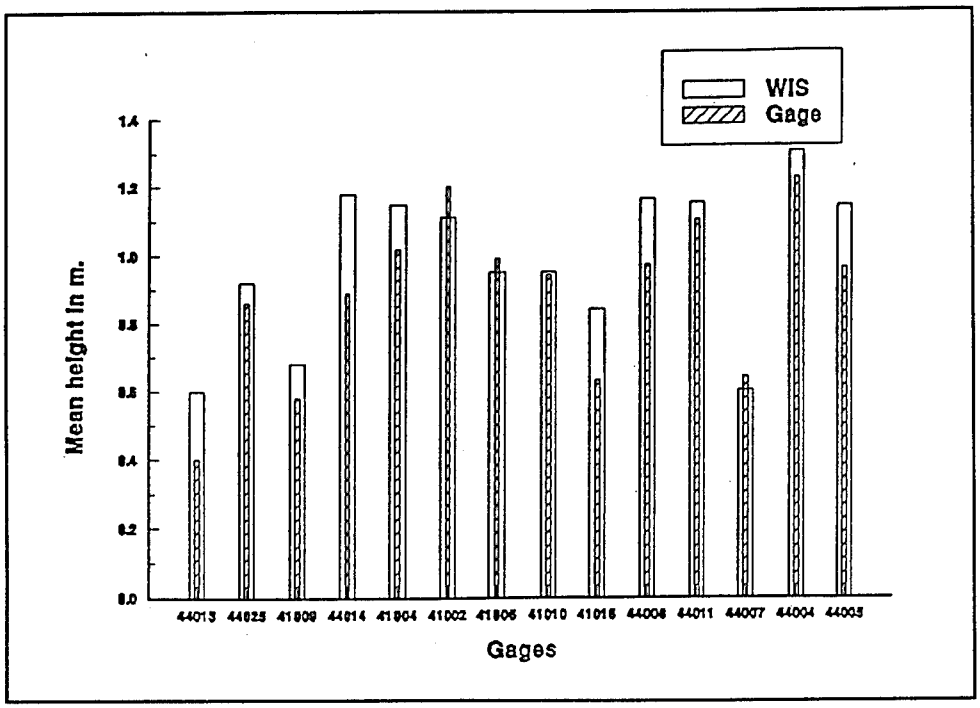


a. Wave height means

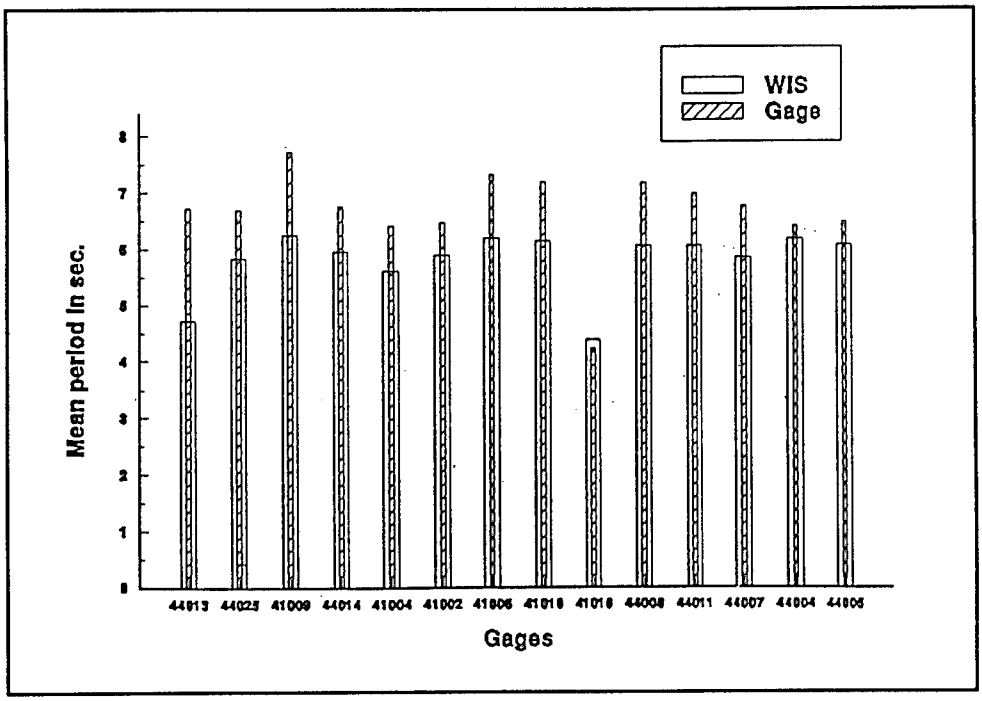


b. Wave period means

Figure 13. Wave information for June 1994

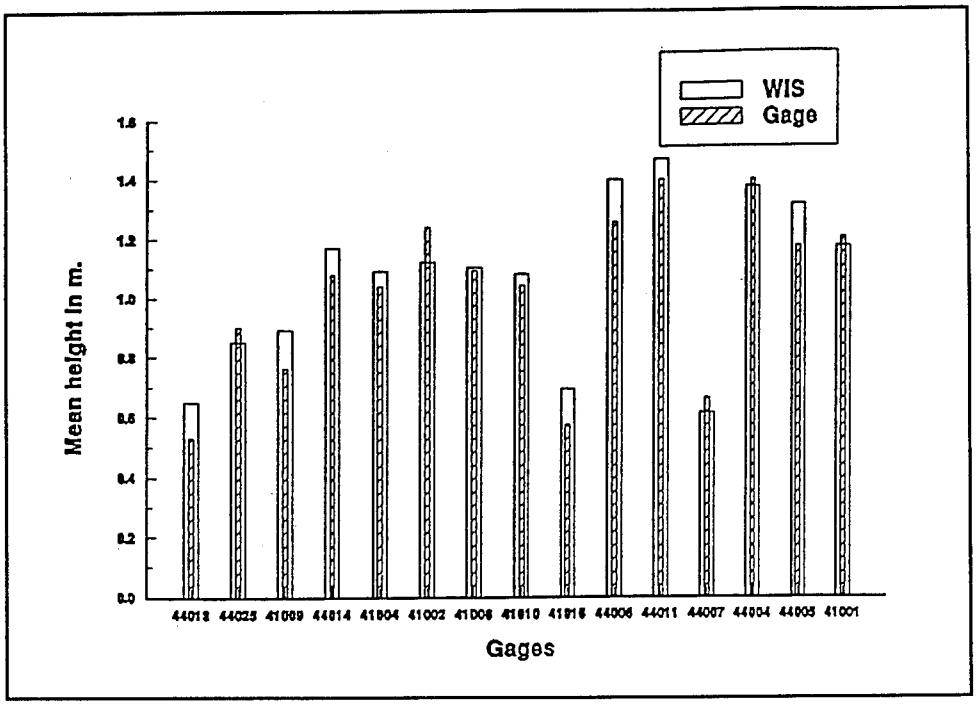


a. Wave height means

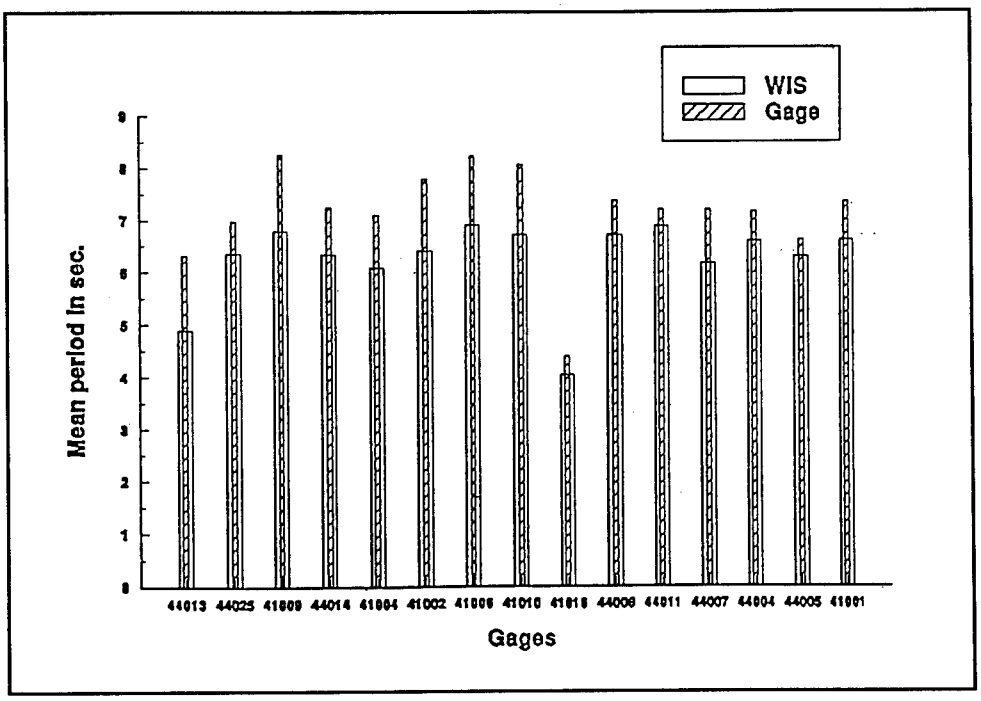


b. Wave period means

Figure 14. Wave information for July 1994

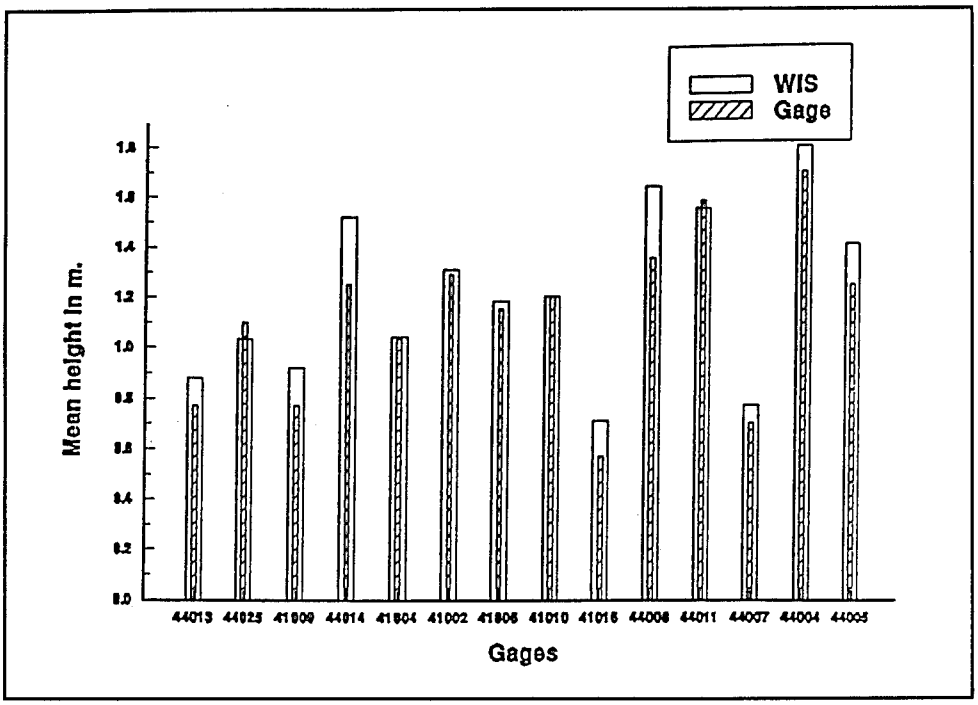


a. Wave height means

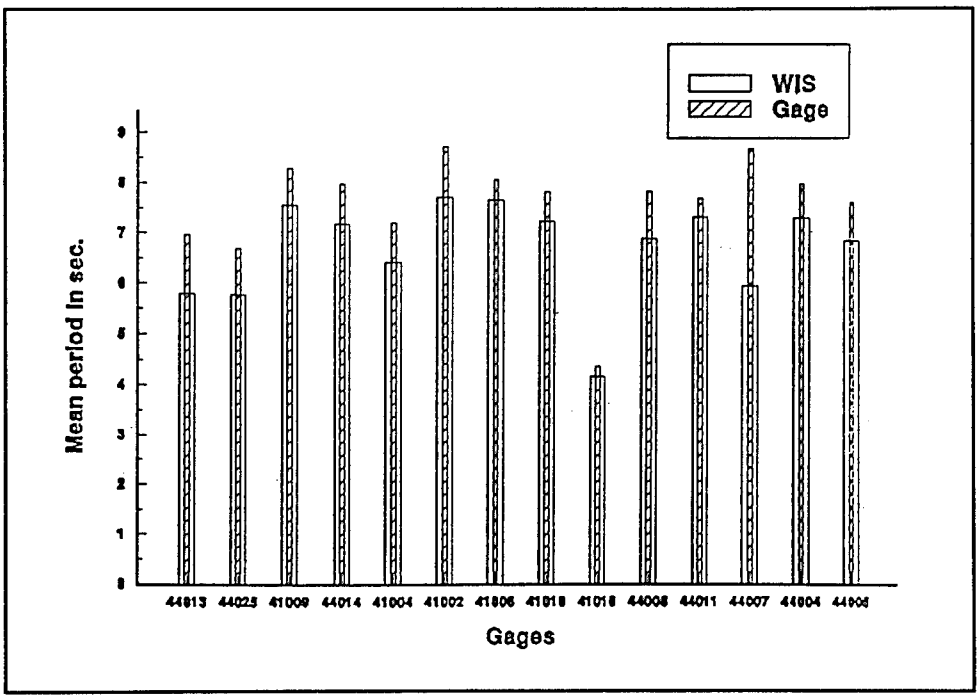


b. Wave period means

Figure 15. Wave information for August 1994

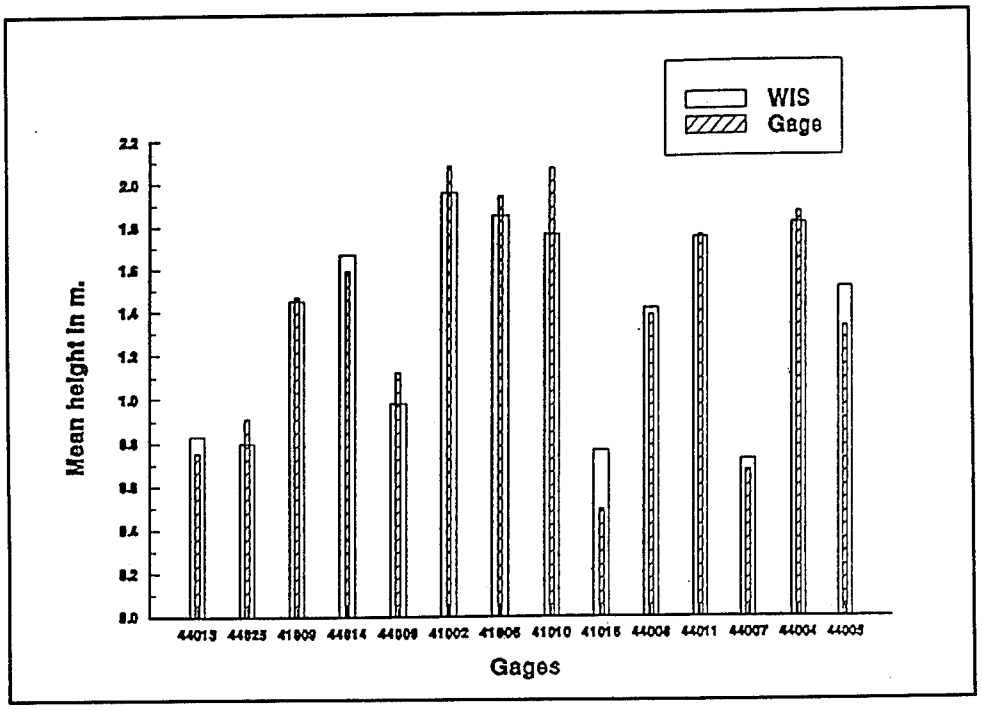


a. Wave height means

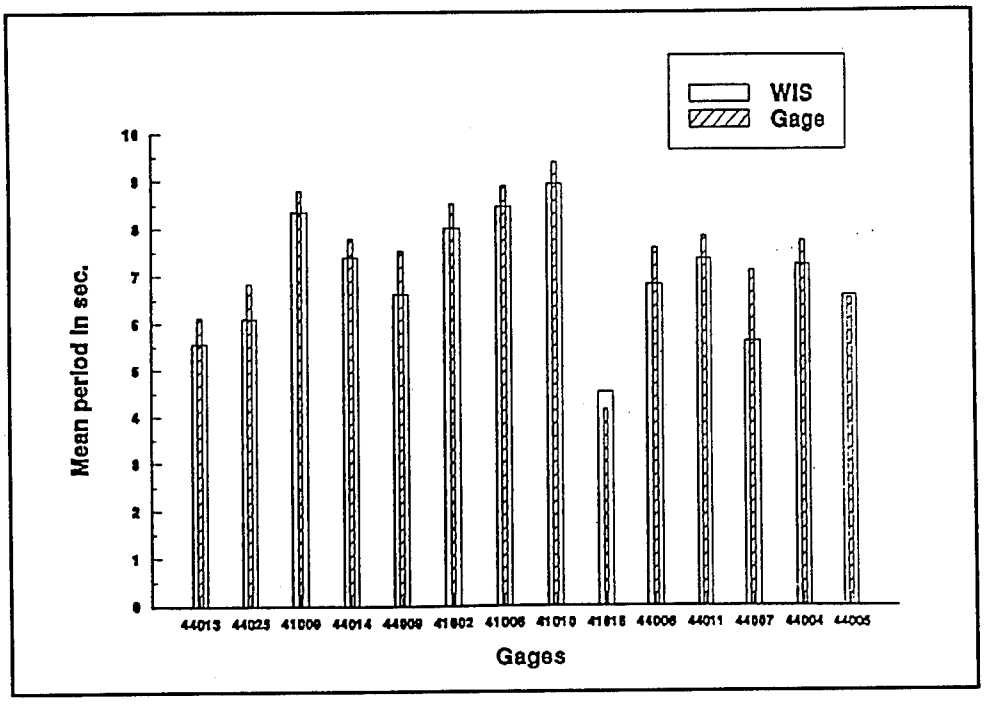


b. Wave period means

Figure 16. Wave information for September 1994

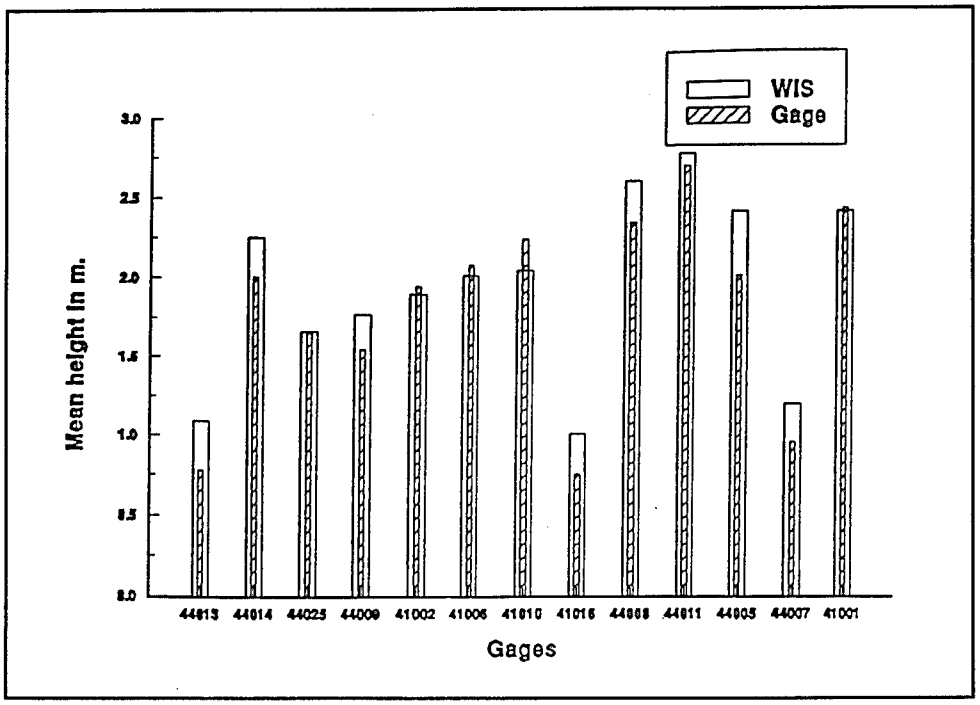


a. Wave height means

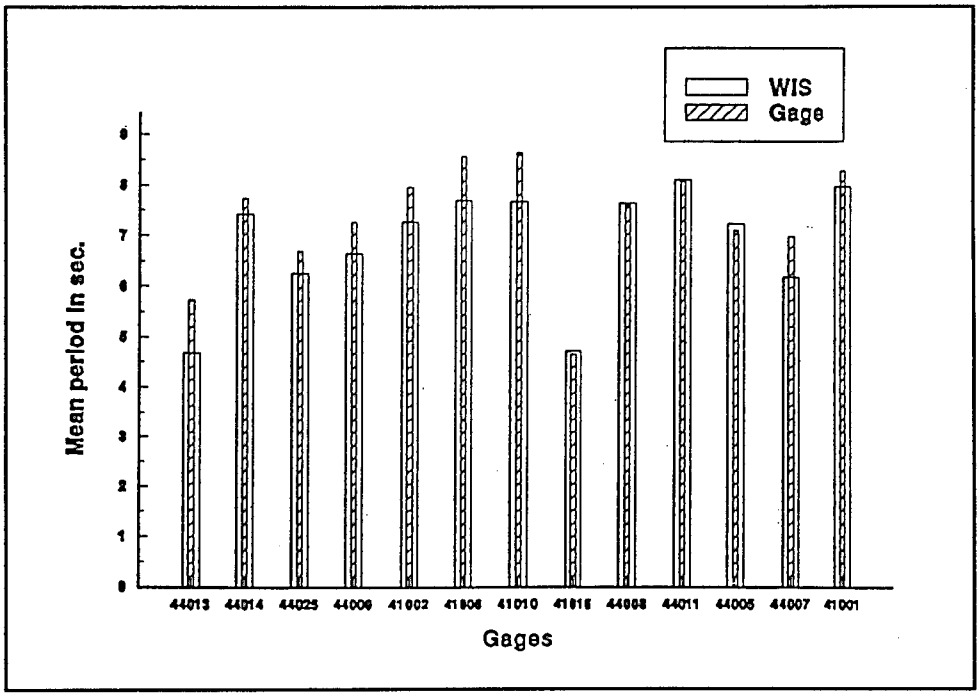


b. Wave period means

Figure 17. Wave information for October 1994

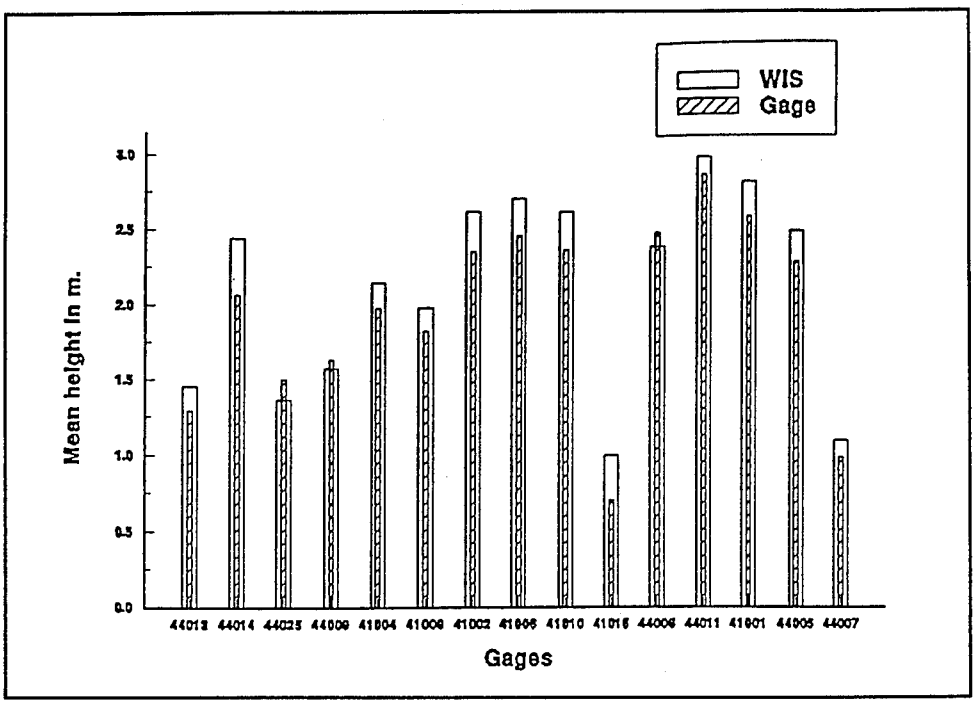


a. Wave height means

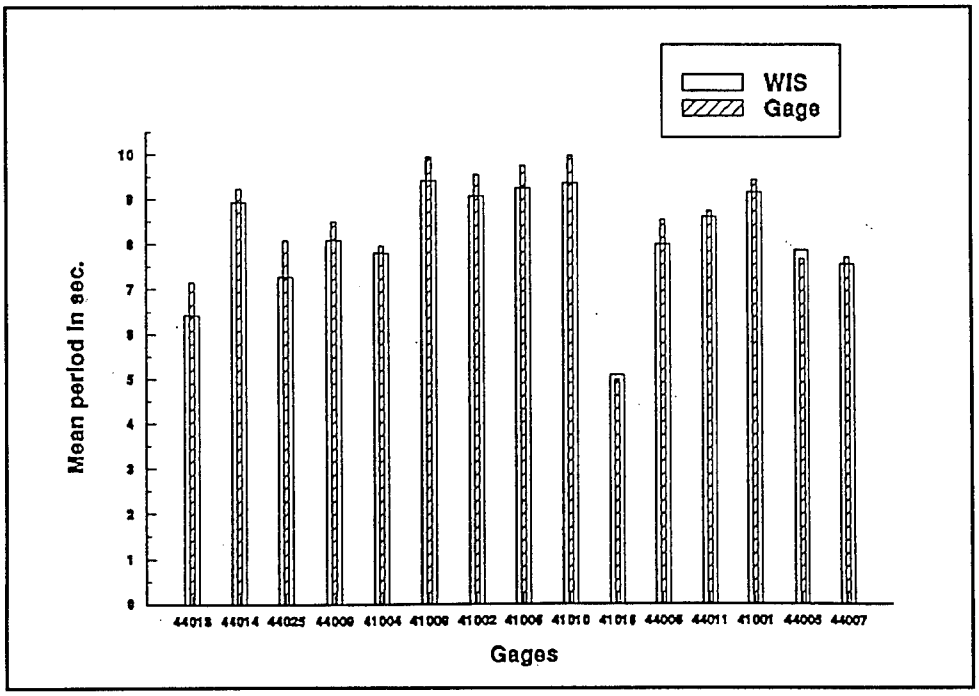


b. Wave period means

Figure 18. Wave information for November 1994

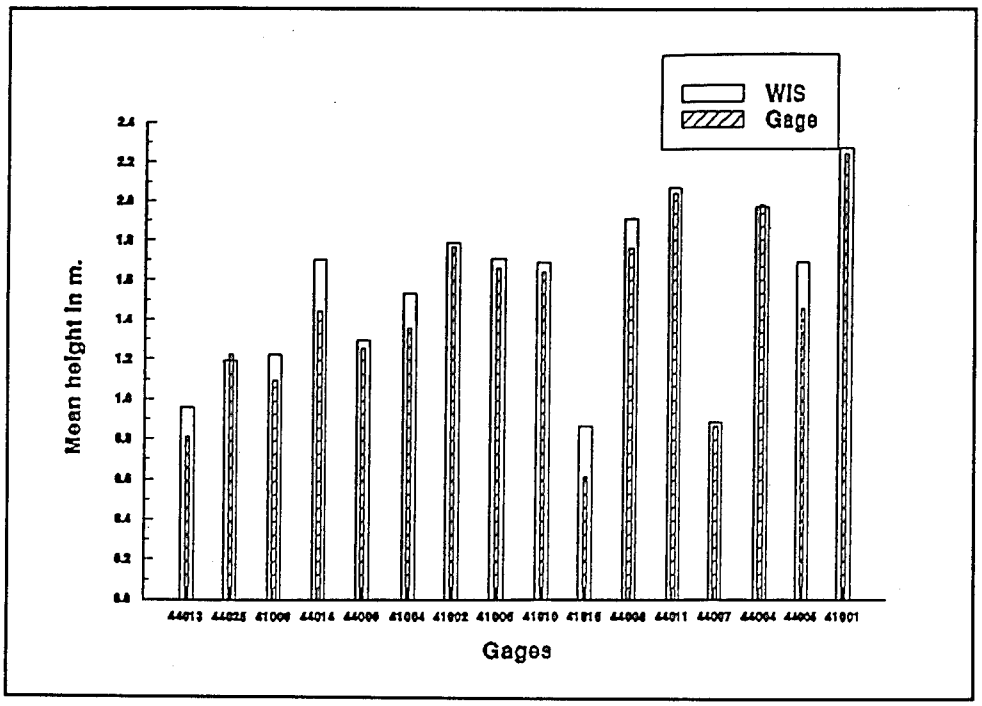


a. Wave height means

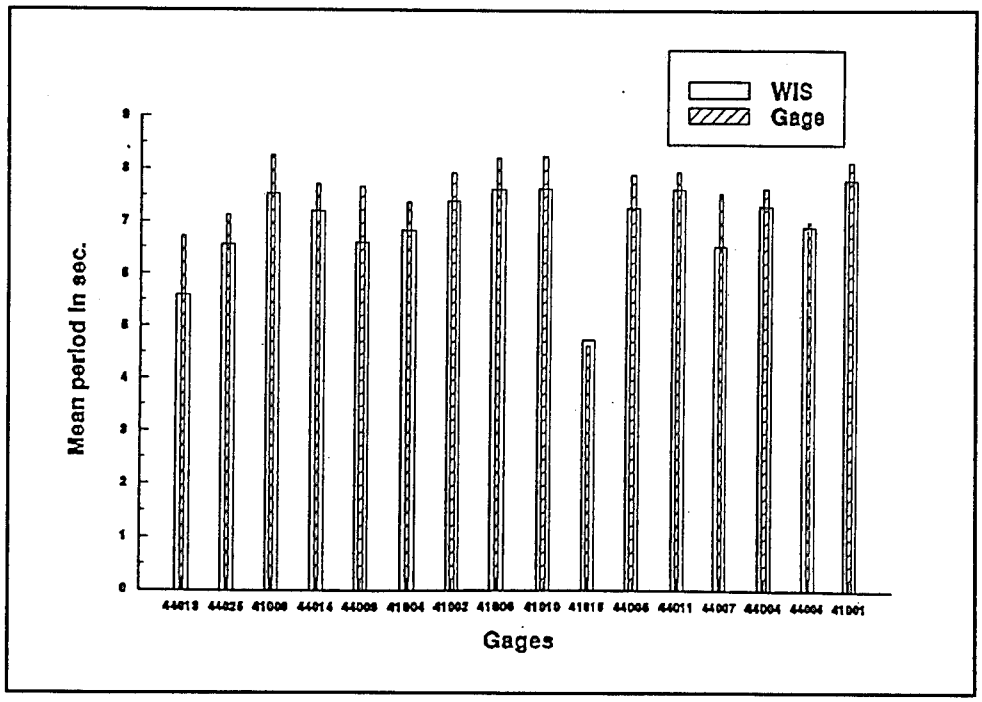


b. Wave period means

Figure 19. Wave information for December 1994



a. Wave height means



b. Wave period means

Figure 20. Wave information for 1994

Table 14
Atlantic Ocean, 1994

		Hs (m)			*Tp* (sec)			*Dp* (deg)			*Ws* (m/s)			*Wd* (deg)		
Gauge	Station	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases	Bias	RMSD	Cases
44013	94	.2	.5	2820	-1.1	2.8	2819	37.3	80.6	2679	.8	2.5	2124	19.6	53.0	2103
44025	116	.0	.4	2818	-.6	1.9	2816	11.8	56.1	2808	-.2	2.2	2812	16.0	49.2	2785
41009	19	.1	.4	2246	-.7	1.6	2243	3.8	36.0	1991	-.7	2.2	2253	.1	52.1	2228
44014	124	.3	.7	2101	-.5	1.9	2098	9.8	65.2	2088	1.4	2.8	2176	14.5	48.3	2150
44009	119	.0	.5	1175	-1.1	2.6	1175	30.6	69.4	1164	.9	2.6	1639	22.0	55.0	1611
41004	130	.2	.5	2100	-.5	1.7	2100	10.5	54.8	2094	.6	2.3	1291	9.7	47.4	1281
41002	131	.0	.5	2757	-.6	1.6	2757	.0	.0	0	.6	1.9	2524	8.9	42.2	2492
41006	137	.0	.4	2827	-.6	1.5	2827	.0	.0	0	.1	1.9	2830	12.7	41.5	2809
41010	138	.0	.5	2809	-.6	1.6	2809	.0	.0	0	.5	2.1	2809	9.7	45.2	2790
41016	139	.2	.4	2673	.1	1.3	2656	.0	.0	0	-.1	1.6	2828	-3.9	32.8	2822
44008	115	.1	.7	2873	-.6	1.9	2873	.0	.0	0	1.4	2.7	2340	17.7	43.5	2311
44011	113	.0	.7	2797	-.3	1.5	2796	.0	.0	0	1.5	2.9	2750	12.6	42.5	2720
44007	109	.0	.4	2476	-1.0	2.8	2475	.0	.0	0	.4	2.3	2313	22.0	56.5	2291
44004	121	.0	.6	2169	-.3	1.6	2169	.0	.0	0	.6	2.4	2167	7.8	38.5	2143
44005	111	.2	.6	2080	-.1	1.9	2074	.0	.0	0	1.1	2.5	1632	11.2	38.5	1615
41001	128	.0	.7	1838	-.3	1.6	1838	.0	.0	0	.9	2.5	1842	11.6	47.7	1815

Bias = model - gauge.
Direction from compass.
Values every 3 hr, 2920 possible.

4 Model Results

Hindcast results for 1994 were tabulated for every fifth station shown in Figure 3. The 1994 data for all the stations shown in Figure 3 are available from the CEDRS database. Table 15 lists the 1994 mean wave heights for every fifth output station beginning with station 5. Monthly means and a yearly mean are shown. Table 16 lists the monthly and yearly peak mean periods for the same group of stations. Table 17 lists the 1994 maximum significant wave height for each month and the maximum significant wave height for the year for the selected Atlantic output stations. The associated period and direction of each maximum wave are also included. Periods are in seconds and directions are in meteorological convention.

Appendix A contains a copy of the last page of the output station information in WIS Report 33 (Brooks and Brandon 1995) for the Atlantic update (1976-1993) for Station 5. Similar tables for the other stations can be found in WIS Report 33 (Brooks and Brandon 1995) or the CEDRS database and will not be reproduced in this report. Comparison of the 1994 means and maximum values with the update means and maxima gives an indication of the 1994 wave climate. The 1994 maximum wave height at station 5 was higher than the update maximum because this station was influenced by Hurricane Gordon in November 1994. The rest of the 1994 maximum waves fall below the update maxima. The mean wave heights for 1994 are generally equal or 0.1 m lower than the update means. The 1994 mean peak periods are about 1 sec lower than the update mean peak periods. The lower mean wave heights and lower mean periods for 1994 indicate that 1994 did not have many severe storms.

Table 15
Mean Wave Heights (m)

WIS Station	January	February	March	April	May	June	July	August	September	October	November	December	1994
5	1.4	1.1	0.9	1.1	0.6	0.7	0.9	0.8	0.8	0.7	1.3	1.0	0.9
10	1.4	1.2	1.0	1.1	0.8	0.6	0.7	0.7	0.8	1.0	1.3	1.3	1.0
15	1.7	1.8	1.4	1.4	1.1	0.7	0.7	0.9	0.9	1.4	1.7	1.9	1.3
20	1.7	1.7	1.4	1.4	1.2	0.8	0.7	0.9	1.0	1.5	1.8	2.0	1.3
25	1.3	1.4	1.1	1.2	1.1	0.7	0.6	0.9	0.9	1.4	1.6	1.8	1.2
30	1.2	1.2	1.0	1.0	1.0	0.7	0.7	0.8	0.8	1.2	1.3	1.4	1.0
35	1.3	1.3	1.2	1.0	1.0	0.9	0.9	0.8	0.7	1.1	1.2	1.4	1.1
40	1.3	1.2	1.3	0.9	1.0	0.9	0.9	0.8	0.7	1.0	1.2	1.4	1.1
45	1.5	1.4	1.5	1.1	1.2	1.2	1.1	0.9	0.9	1.2	1.4	1.5	1.2
50	1.6	1.4	1.5	1.1	1.2	1.2	1.1	0.9	0.9	1.2	1.5	1.6	1.3
55	2.0	1.6	1.9	1.3	1.5	1.1	1.0	1.0	1.3	1.6	1.9	2.2	1.5
60	1.4	1.2	1.4	1.0	1.1	0.9	0.8	0.8	1.0	1.1	1.5	1.6	1.1
65	1.2	1.1	1.3	0.9	1.0	0.8	0.8	0.7	0.8	0.8	1.4	1.3	1.0
70	1.2	1.0	1.2	0.9	0.9	0.8	0.7	0.7	0.8	0.6	1.3	1.2	0.9
75	1.4	1.1	1.4	1.0	1.0	0.9	0.9	0.8	0.9	0.7	1.5	1.2	1.1
80	1.7	1.4	1.7	1.2	1.2	1.1	1.1	1.0	1.1	0.8	1.7	1.4	1.3
85	1.7	1.4	1.7	1.3	1.2	1.1	1.1	1.0	1.1	0.8	1.7	1.3	1.3
90	1.9	1.6	1.8	1.3	1.4	1.0	0.9	1.0	1.1	1.1	1.7	1.8	1.4
95	1.3	1.2	1.2	0.8	0.9	0.7	0.6	0.6	0.9	0.8	1.1	1.4	0.9
100	1.7	1.3	1.6	1.2	1.2	0.9	0.8	0.8	0.9	0.9	1.5	1.4	1.2
105	1.9	1.4	1.8	1.4	1.4	1.2	1.0	1.1	1.0	1.1	1.7	1.5	1.4

Table 16 Mean Wave Periods (sec)

WIS Station	January	February	March	April	May	June	July	August	September	October	November	December	1994
5	5.6	5.5	5.1	5.5	5.5	4.6	4.8	4.6	5.3	5.7	6.2	6.2	5.4
10	6.2	6.7	6.6	5.8	6.6	5.2	4.3	5.0	6.2	8.1	7.4	8.7	6.4
15	7.9	8.7	8.1	8.2	8.3	6.8	5.8	6.9	7.9	9.2	8.4	9.6	8.0
20	8.1	8.6	7.9	7.8	7.9	6.8	6.3	6.8	7.8	8.6	8.2	9.5	7.8
25	8.3	8.5	8.0	8.0	7.7	6.7	6.1	6.6	7.5	8.5	8.1	9.6	7.8
30	8.2	8.3	7.8	7.5	7.5	6.2	6.2	6.7	7.0	8.3	7.9	9.2	7.6
35	7.8	7.7	6.6	7.0	6.5	5.8	5.4	6.3	6.3	6.3	7.6	7.3	6.7
40	7.6	7.4	6.9	7.6	6.6	6.3	5.7	6.0	7.0	7.7	6.9	8.6	7.0
45	7.4	7.0	6.9	6.9	6.4	6.3	5.6	6.0	6.8	7.3	6.4	8.1	6.8
50	7.6	7.1	7.1	7.2	6.6	6.5	5.7	6.0	6.9	7.2	6.5	8.3	6.9
55	7.4	7.0	7.3	7.9	6.8	6.2	5.2	5.8	7.1	7.3	6.9	8.6	6.9
60	6.9	7.1	7.2	7.4	6.4	5.6	5.3	5.7	6.9	6.7	6.5	8.4	6.7
65	7.0	6.9	7.5	7.1	6.3	5.6	5.1	5.7	6.2	6.5	6.5	8.0	6.5
70	8.6	7.2	8.8	7.7	7.0	6.4	5.9	6.3	6.3	7.0	7.2	9.1	7.3
75	7.7	6.5	8.0	6.9	6.7	6.1	5.8	6.2	5.8	6.2	6.5	7.3	6.7
80	7.9	6.7	8.2	7.1	7.0	6.2	6.0	6.5	6.0	6.4	6.7	6.9	6.8
85	7.4	6.3	8.1	7.0	6.7	6.1	6.0	6.3	5.7	5.6	6.6	6.5	6.5
90	8.0	7.1	8.7	7.2	7.1	6.2	5.7	6.4	6.3	6.4	7.3	7.8	7.0
95	6.3	5.7	7.4	6.6	6.0	5.3	4.5	4.7	5.6	5.8	5.0	6.8	5.8
100	7.8	6.6	8.5	7.0	7.2	6.3	5.7	6.4	5.5	6.1	6.7	7.8	6.8
105	7.9	6.9	8.7	7.3	7.2	6.6	6.0	6.8	5.5	6.0	7.0	7.4	6.9

Table 17
Maximum Wave Height (m) with Associated Period (sec) and Direction (deg)

WIS Station	January	February	March	April	May	June	July	August	September	October	November	December	1994
	3.1	2.7	2.9	2.6	1.7	1.4	2.2	1.9	2.1	2.4	6.2	3.9	6.2
	8.0	8.0	8.0	8.0	5.0	5.0	7.0	7.0	7.0	6.0	11.0	8.0	11.0
5	47.0	76.0	108.0	104.0	155.0	101.0	119.0	112.0	115.0	58.0	137.0	176.0	137.0
	3.1	4.0	3.6	2.0	2.7	1.2	1.4	1.5	1.6	2.8	5.7	3.6	5.7
	8.0	9.0	9.0	7.0	10.0	5.0	6.0	6.0	12.0	7.0	12.0	9.0	12.0
10	22.0	61.0	166.0	101.0	25.0	133.0	115.0	112.0	29.0	36.0	54.0	133.0	54.0
	4.1	6.0	4.0	2.2	3.9	1.0	1.2	1.2	2.0	3.7	5.1	5.3	6.0
	10.0	13.0	9.0	8.0	10.0	8.0	5.0	6.0	13.0	11.0	12.0	10.0	13.0
15	65.0	79.0	162.0	50.0	25.0	68.0	166.0	104.0	43.0	43.0	65.0	47.0	79.0
	3.6	5.0	3.9	2.3	4.5	1.1	1.3	1.4	2.2	3.8	4.6	4.4	5.0
	10.0	12.0	8.0	8.0	10.0	4.0	5.0	5.0	7.0	10.0	11.0	12.0	12.0
20	68.0	86.0	137.0	58.0	36.0	227.0	187.0	151.0	86.0	47.0	68.0	72.0	86.0
	2.9	3.8	3.5	2.1	2.9	1.2	1.2	1.7	1.9	3.2	3.5	4.1	4.1
	9.0	11.0	8.0	8.0	10.0	5.0	5.0	7.0	8.0	11.0	10.0	12.0	12.0
25	76.0	90.0	151.0	65.0	65.0	148.0	184.0	68.0	61.0	65.0	79.0	90.0	90.0
	2.6	3.1	3.9	1.9	1.9	1.3	1.4	1.6	1.8	3.4	2.8	3.8	3.9
	9.0	10.0	10.0	8.0	9.0	5.0	5.0	6.0	8.0	10.0	10.0	13.0	10.0
30	115.0	104.0	126.0	97.0	90.0	173.0	202.0	144.0	86.0	101.0	90.0	108.0	126.0

(Sheet 1 of 4)

Table 17 (Continued)

WIS Station	January	February	March	April	May	June	July	August	September	October	November	December	1994
	3.9	2.7	4.7	1.7	1.9	2.1	2.1	1.9	1.8	3.3	2.7	4.2	4.7
	9.0	10.0	10.0	7.0	6.0	7.0	7.0	7.0	9.0	10.0	9.0	13.0	10.0
35	144.0	122.0	151.0	169.0	180.0	162.0	176.0	151.0	101.0	112.0	90.0	126.0	151.0
	4.2	2.4	5.5	2.1	2.0	2.2	2.1	1.4	1.6	2.6	3.6	4.1	5.5
	10.0	8.0	11.0	8.0	8.0	9.0	7.0	6.0	7.0	9.0	13.0	14.0	11.0
40	155.0	176.0	162.0	166.0	101.0	173.0	180.0	144.0	94.0	101.0	94.0	133.0	162.0
	5.5	4.4	6.2	3.3	2.8	3.5	2.7	1.6	2.1	3.2	4.4	4.6	6.2
	11.0	10.0	11.0	8.0	7.0	9.0	8.0	6.0	8.0	8.0	12.0	13.0	11.0
45	169.0	184.0	166.0	180.0	198.0	184.0	187.0	202.0	79.0	79.0	112.0	115.0	166.0
	5.4	4.2	5.4	3.3	3.3	3.3	2.5	2.0	2.8	3.6	6.2	4.9	6.2
	11.0	9.0	11.0	9.0	9.0	9.0	7.0	7.0	8.0	9.0	12.0	12.0	12.0
50	162.0	187.0	155.0	176.0	104.0	180.0	198.0	205.0	104.0	101.0	126.0	119.0	126.0
	5.6	4.4	5.5	4.0	4.4	4.1	2.6	2.3	5.9	5.5	8.8	6.2	8.8
	11.0	9.0	10.0	8.0	9.0	9.0	7.0	7.0	12.0	11.0	13.0	13.0	13.0
55	158.0	176.0	122.0	187.0	94.0	173.0	191.0	14.0	47.0	79.0	97.0	58.0	97.0
	3.5	2.4	4.6	2.9	3.4	3.2	2.5	1.9	3.9	4.0	6.1	5.5	6.1
	7.0	6.0	9.0	7.0	9.0	8.0	7.0	6.0	12.0	11.0	14.0	13.0	14.0
60	216.0	202.0	101.0	184.0	86.0	173.0	184.0	191.0	86.0	76.0	94.0	79.0	94.0

(Sheet 2 of 4)

Table 17 (Continued)

Wis Station	January	February	March	April	May	June	July	August	September	October	November	December	1994
	3.0	2.5	4.3	2.4	4.0	2.9	2.1	1.7	3.9	3.5	5.3	5.1	5.3
	8.0	8.0	11.0	7.0	8.0	7.0	6.0	6.0	9.0	9.0	13.0	11.0	13.0
65	151.0	112.0	104.0	187.0	54.0	184.0	187.0	148.0	112.0	79.0	97.0	97.0	97.0
	3.7	2.9	5.3	2.0	3.4	2.7	1.8	1.7	3.1	2.4	4.2	4.7	5.3
	8.0	9.0	12.0	6.0	10.0	7.0	7.0	7.0	11.0	9.0	13.0	12.0	12.0
70	169.0	112.0	122.0	187.0	115.0	176.0	191.0	198.0	108.0	115.0	119.0	126.0	122.0
	4.5	3.0	4.9	2.4	2.9	3.2	2.3	2.3	2.8	1.8	3.8	4.0	4.9
	9.0	9.0	12.0	8.0	10.0	8.0	6.0	7.0	9.0	7.0	8.0	12.0	12.0
75	173.0	126.0	140.0	180.0	137.0	176.0	187.0	209.0	133.0	86.0	133.0	144.0	140.0
	5.3	3.2	6.2	2.7	3.7	3.3	2.6	2.9	3.1	2.0	4.6	4.9	6.2
	10.0	8.0	10.0	8.0	7.0	8.0	7.0	9.0	9.0	6.0	10.0	8.0	10.0
80	176.0	97.0	86.0	187.0	36.0	187.0	191.0	205.0	133.0	65.0	180.0	25.0	86.0
	5.0	3.4	4.5	2.8	2.8	2.7	2.3	3.2	3.0	2.2	4.5	3.6	5.0
	11.0	10.0	10.0	7.0	11.0	8.0	8.0	10.0	7.0	7.0	10.0	13.0	11.0
85	187.0	173.0	166.0	194.0	166.0	194.0	202.0	202.0	137.0	216.0	187.0	173.0	187.0
	4.8	4.0	5.0	2.8	3.6	2.4	1.9	2.9	4.1	2.6	4.8	5.0	5.0
	10.0	9.0	13.0	8.0	10.0	8.0	7.0	8.0	10.0	7.0	10.0	12.0	13.0
90	162.0	169.0	176.0	176.0	162.0	184.0	194.0	32.0	32.0	4.0	184.0	166.0	176.0

(Sheet 3 of 4)

Table 17 (Concluded)

WIS Station	January	February	March	April	May	June	July	August	September	October	November	December	1994
	4.7	3.2	4.3	2.4	2.6	1.8	1.7	2.3	4.1	2.0	3.4	5.3	5.3
	9.0	9.0	9.0	6.0	7.0	6.0	6.0	6.0	9.0	6.0	7.0	9.0	9.0
95	65.0	76.0	90.0	184.0	58.0	184.0	191.0	36.0	61.0	40.0	198.0	40.0	40.0
	4.8	3.6	4.7	4.1	3.1	2.4	2.2	2.2	3.1	2.2	5.1	4.2	5.1
	9.0	8.0	13.0	10.0	10.0	8.0	7.0	6.0	9.0	9.0	10.0	12.0	10.0
100	176.0	104.0	173.0	169.0	155.0	176.0	184.0	234.0	119.0	144.0	169.0	166.0	169.0
	6.1	4.6	4.3	5.0	3.3	3.7	2.9	4.0	2.8	2.7	4.5	3.8	6.1
	10.0	9.0	9.0	10.0	9.0	8.0	8.0	9.0	8.0	8.0	9.0	9.0	10.0
105	184.0	202.0	151.0	191.0	205.0	202.0	202.0	212.0	212.0	202.0	180.0	187.0	184.0

(Sheet 4 of 4)

5 Data Availability

The WIS hindcast data are available on the computer internet by anonymous file transfer protocol (ftp). Information about obtaining this data may be viewed at World Wide Web site http://www.wes.army.mil by selecting the Coastal Engineering Research Center. If a Web browser is not available, the following instructions will be of assistance:

ftp 134.164.160.40

id: anonymous

password: your email address

cd /pub/atl

The file entitled README.NOW will give instructions about downloading data. For help or additional information, please contact the following by email:

webmaster@coafs1.wes.army.mil

This report is the first in a yearly series of nowcast reports. The WIS is attempting to make current wave information available for coastal projects. The NMC wind fields provide an accurate representation of the 1994 wind climate. Monthly comparisons with measurements provide quality control on the numerical wave output data. The ability to redefine the hurricane winds with the HURWIN process gives more realistic hurricane wave results. New procedures to redefine other nontropical storms will be added to the procedure as they become available.

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Appendix A
Atlantic Update Tables

WIS ATLANTIC UPDATE -- WITH HURRICANES 1976 - 1993
LAT: 25.00 N, LONG: 80.25 W, DEPTH: 183 M

STATION: 5

OCCURRENCES OF WIND DIRECTION BY MONTH FOR ALL YEARS

DIRECTION	WD(deg) BAND & CENTER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
337.50 - 22.49	(0.0)	859	578	497	388	180	71	90	112	182	543	568	678	4746
22.50 - 67.49	(45.0)	997	826	768	714	581	416	303	379	794	1734	1441	1345	10298
67.50 - 112.49	(90.0)	1175	1136	1417	1565	2108	2041	2611	2579	2245	1405	1472	1407	21161
112.50 - 157.49	(135.0)	567	596	838	727	957	975	899	835	616	327	440	441	8218
157.50 - 202.49	(180.0)	228	238	333	221	249	461	258	186	245	116	120	164	2819
202.50 - 247.49	(225.0)	140	138	157	140	135	181	133	160	102	98	65	83	1532
247.50 - 292.49	(270.0)	155	158	165	231	135	107	95	118	61	74	46	107	1452
292.50 - 337.49	(315.0)	343	402	289	334	119	68	75	95	75	167	168	239	2374
TOTAL		4464	4072	4464	4320	4464	4320	4464	4464	4320	4464	4320	4464	52600

STATION: 5

SUMMARY OF MEAN Hmo(m) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1976	1.08	1.03	1.00	0.80	0.86	0.64	0.50	0.52	0.28	1.03	1.16	1.35	0.85
1977	0.82	0.93	1.07	1.60	1.04	0.46	0.62	0.94	0.52	0.75	1.13	1.01	0.91
1978	0.99	0.83	0.90	0.94	0.66	0.65	0.66	0.58	0.51	1.05	1.07	1.14	0.83
1979	1.42	1.00	1.30	1.28	0.88	0.72	0.69	0.52	1.32	0.81	1.50	1.26	1.06
1980	0.83	0.99	1.00	0.79	0.71	0.51	0.43	0.76	0.57	0.56	1.09	1.22	0.79
1981	0.72	1.68	1.12	1.28	0.63	0.72	0.50	0.87	0.58	0.91	1.10	0.88	0.91
1982	1.02	0.89	1.04	0.73	0.95	0.72	0.55	0.51	0.47	0.83	1.09	1.35	0.85
1983	0.69	1.08	1.15	1.00	0.99	0.47	0.56	0.42	0.78	0.89	0.81	1.02	0.82
1984	1.24	1.15	1.08	0.85	1.02	0.71	0.64	0.54	0.85	1.23	1.26	1.35	0.99
1985	0.73	1.31	1.07	0.99	0.45	0.48	0.53	0.69	0.97	0.93	1.22	1.02	0.86
1986	0.99	0.76	1.28	0.68	1.03	0.59	0.52	0.76	0.81	0.91	1.14	1.17	0.89
1987	0.88	1.00	1.44	0.61	0.84	0.75	0.70	0.55	0.37	0.98	1.43	0.96	0.88
1988	1.32	0.98	1.09	0.77	0.84	0.82	0.65	0.57	1.06	0.85	0.94	0.92	0.90
1989	0.79	0.90	0.82	0.60	0.58	0.59	0.47	0.38	0.51	0.54	0.72	0.56	0.62
1990	0.94	1.32	1.33	1.04	0.99	0.79	0.64	0.35	0.68	0.90	1.17	1.15	0.94
1991	0.81	0.85	0.99	1.05	1.06	0.40	0.41	0.43	0.42	0.87	0.97	1.01	0.77
1992	0.86	0.91	0.88	1.00	0.74	0.71	0.84	0.70	0.64	0.86	1.26	0.92	0.86
1993	1.12	0.91	1.00	0.94	0.97	0.72	0.46	0.53	0.70	0.60	1.03	0.90	0.82
MEAN	0.96	1.03	1.09	0.94	0.85	0.64	0.58	0.59	0.67	0.86	1.12	1.07	

STATION: 5

MAX Hmo(m)*10 WITH ASSOCIATED Tp(sec) AND Dp(deg/10) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MAX
1976	35 8 7	42 9 7	35 8 7	41 9 9	33 812	14 610	13 610	19 6 8	7 4 8	33 8 5	34 8 5	40 9 2	42 9 7
1977	25 8 7	25 7 5	30 8 7	46 9 8	33 9 7	11 510	12 510	28 8 9	23 710	29 9 6	36 8 6	38 8 5	46 9 8
1978	25 717	36 8 4	30 717	32 813	23 717	33 8 8	25 710	20 6 9	23 711	31 8 5	38 8 4	5410 7	5410 7
1979	50 9 5	30 8 9	40 9 8	381015	38 8 5	32 8 7	27 912	15 5 7	44 9 6	27 8 8	36 9 4	50 9 5	50 9 5
1980	22 719	35 8 4	36 8 7	31 815	27 8 8	24 7 7	16 610	551114	17 6 8	17 6 7	30 7 7	31 8 5	551114
1981	21 6 7	5310 5	33 812	42 9 6	19 613	23 711	22 6 9	51 916	25 7 9	39 8 6	44 9 7	55 713	5310 5
1982	39 822	43 910	46 9 9	31 710	31 8 7	38 817	18 712	13 510	11 5 9	23 7 8	38 8 6	34 810	46 9 9
1983	25 7 8	39 8 8	48 916	30 813	27 810	12 512	18 7 9	11 5 9	29 8 6	40 8 7	34 8 5	2711 3	48 916
1984	42 9 6	36 8 6	32 821	22 610	29 7 7	18 7 9	20 612	24 712	45 9 8	29 8 5	34 8 5	43 9 8	45 9 8
1985	24 810	40 8 8	41 8 7	59 8 9	11 5 6	23 711	17 620	28 8 8	32 8 5	28 8 8	601014	32 8 8	601014
1986	37 8 7	29 7 9	35 912	24 7 8	28 810	17 6 7	19 7 9	20 710	22 7 8	37 8 4	30 8 6	41 913	41 913
1987	33 817	29 812	53 9 8	18 615	45 913	27 813	22 710	17 6 9	8 411	43 819	41 9 9	38 8 9	53 9 8
1988	52 9 9	27 8 9	31 8 9	28 7 9	35 8 8	39 814	21 610	17 6 3	431014	30 8 5	19 6 5	30 7 8	52 9 9
1989	31 810	31 7 7	21 532	18 610	18 613	12 514	12 510	16 6 8	11 512	21 6 4	24 7 6	16 533	31 7 7
1990	24 7 8	35 8 7	39 9 8	31 8 8	23 713	15 5 7	15 5 9	12 5 9	11 510	24 7 7	27 8 5	39 9 5	39 9 5
1991	26 710	20 7 8	35 819	32 8 6	441011	13 5 8	12 510	10 5 9	12 5 7	31 714	27 7 8	44 9 7	44 9 7
1992	25 813	26 817	24 7 9	24 7 7	17 6 8	12 517	15 610	40 818	18 710	35 8 5	33 8 5	23 7 4	40 818
1993	31 8 8	27 8 4	49 918	25 810	22 7 9	22 7 8	13 611	17 610	22 7 3	26 819	26 8 5	34 8 6	49 918
MAX	52 9 9	5310 5	53 9 8	46 9 8	45 913	39 814	34 912	551114	45 9 8	43 819	601014	5410 7	

MAX Hmo(m): 6.0 MAX Tp(sec): 10. MAX Dp(deg): 140. DATE(gmt): 85112000

MAX WIND SPEED(m/sec): 27. MAX WIND DIRECTION(deg): 250. DATE(gmt): 92082409

MEAN Hmo(m): 0.9 MEAN Tp(sec): 6.

STANDARD DEVIATION Hmo(m): 0.6 STANDARD DEVIATION Tp(sec): 2.6

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The Wave Information Studies (WIS) project has provided wave information for nearshore U.S. Atlantic coast locations for the years 1956-1993. This information has provided coastal engineers with an authoritative, long-term database with which to evaluate coastal processes and design appropriate management strategies for the coastline. A "nowcast" procedure was established to meet the need to update the wave database with recent information. This report describes the nowcasting procedure for the Atlantic and provides a description and analysis of the wave climatology for 1994.

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